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IN THIS ISSUE:

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Contents

THE IDEAL AIRPORT

The Airport - Symbol of the Modern Age 179

The Ideal Airport R. LEMAIRE, PARIS 180

The Life of a Traffic Controller C. ROBERTS, WASHINGTON 187

An Airline Operator's Point of View A. PLESMAN, AMSTERDAM 190

Airport Economics Still Far from Ideal G. C. v. WAGENINGEN, SCHEVENINGEN 191

World's Largest Airport System - New York H. LEVY & W.D. SHIPP, NEW YORK 195

The World's Major Airports 199

Beirut International Airport P. PIVOT, PARIS 205

Radio at Rangoon B. J. O'KANE, LONDON 207

What's in the Air ? 209

THE IDEAL AIRPORT (*cont'd*)

The Meteorological Teleprinter Service P. WÜSTHOFF, STUTTGART 211

ICAO Abbreviations for Radio Facilities 212

VHF Omni-Directional Range Navigation R. W. THWING, NEW YORK 213

Front Cover:

Washington National Airport. Night brings no let-up in tower operations.

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UNITED AIRGRAM

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Dear Sir:

Because we are interested in the efficiency and success of users of our equipment, we try to keep pace with their requirements for spare parts and major components. In this regard, we sincerely believe our manufacturing divisions have an excellent record, especially when the operators themselves have used enough foresight regarding their needs.

But, the stepped-up military program of this country places upon us a grave responsibility. Military requirements must be met, unfailingly. To this end, we have recently licensed the Ford Motor Company to build Wasp Majors, and Chrysler Corporation, J-48 Turbo Wasps. So far, our military demands have been filled and it has also been possible to keep supplying our domestic commercial and export customers with reasonable dispatch. However, as military demands grow, it is possible that a diversion of some materials might be unavoidable.

It is also becoming more and more difficult for us to obtain materials from our own suppliers and delivery time has increased greatly. For instance, the completion time on orders for new engines going through our Pratt & Whitney plant has increased to fourteen months and may, of necessity, be further increased.

So, we urge our customers to continually study future requirements for spare units and spare parts, so that orders with proper priority ratings can be placed sufficiently in advance to compensate for current and potential delivery delays. In emergency cases, we will do everything we can to supply materials sufficient to keep aircraft flying, but there will surely be more frequent cases of emergency, with consequent greater load upon our capacity. These conditions, together with rapidly increasing cost of labor and materials, should receive your full consideration in planning future orders.

WESTLAND GETS SIKORSKY S-55 LICENSE. Westland Aircraft, Ltd., largest helicopter factory in Europe, recently signed a license agreement under which S-55 Sikorsky helicopters will be built in England. Westland has been building the Sikorsky S-51 since 1947.

Because the S-55 requires an engine power in excess of that provided by the engine at present generally installed in British helicopters, Westland will use the American Pratt & Whitney R-1340 (600 h.p.) and will further explore the possibility of British manufacturers producing an all-British power unit.

The S-55 has 6,800 pounds gross weight — useful load of 2,405 pounds -- high speed of 110 m.p.h. -- cruising speed of 86 m.p.h. The S-55 is being produced at Bridgeport by Sikorsky for the U.S. Air Force (designation: H-19) and the Navy and Marine Corps (designation: HO4S-1).

WINDMILLS AT WAR -- The Sikorsky Helicopter Meets The Acid Test. In Korea, under the most trying conditions, Sikorsky Helicopters have performed such extraordinary feats in rescue and liaison work that they have attracted world-wide attention. In places where no other form of transport, air or surface, could perform, Sikorsky helicopters have functioned with outstanding reliability and efficiency.

As just one indication of their accomplishments, we repeat excerpts from a leading New York paper:

"Flying windmills have saved no less than 655 critically wounded soldiers from possible death . . . there seems no doubt that this remarkable flying machine is finally coming into its own. The 655th man rescued was so badly injured that he couldn't have been carried for any distance on a litter . . . the helicopter was able to reach an area unattainable by any other device. Helicopters have never, not even in World War II, played such an important part in military operations as they are doing today and men in the field say there is a great need for even more of them. The successful, large-scale helicopter operations in Korea suggest that peacetime uses for the machines may be far greater than generally anticipated."

NEW PURCHASES NOTE:

Trans World Airlines and Eastern Air Lines will shortly receive the first of their new Martin 4-0-4 airliners. TWA will receive a total of forty and Eastern thirty-five. An improved version of the Martin 2-0-2, the new Martin 4-0-4, is reported to combine unusually low landing speed with high cruising speed. TWA's 4-0-4s will be equipped with Pratt & Whitney R-2800-CB16 (two-speed supercharger) engines suitable for high altitudes. Eastern's will be powered by R-2800-CB3 (single-speed supercharger) engines, suitable for its runs. Both will be equipped with Hamilton Standard 43E60 propellers, incorporating feathering and reversing features. New square-tipped duralumin blades bring substantial advances in structural as well as aerodynamic design.

FORD, CHRYSLER TO BUILD PRATT & WHITNEY ENGINES:

To help meet the rapidly expanding requirements of the Armed Forces, Pratt & Whitney is again licensing automotive manufacturers to build its products. The Ford Motor Company will build the R-4360 Wasp Major engine in a government-owned plant in Chicago, and the Chrysler Corporation will build the J-48 Turbo-Wasp.

IMPORTANT CHANGE-IN-ADDRESS NOTE: European Office, formerly at Rue Montagne Du Parc, 4 Brussels, Belgium, now at: United Aircraft Export Corporation, 3/5 Warwick House Street, London S.W.1, England. Cable: UNITEDAIR LONDON. Inland Telegrams: UNITEDAIR LESQUARE LONDON.

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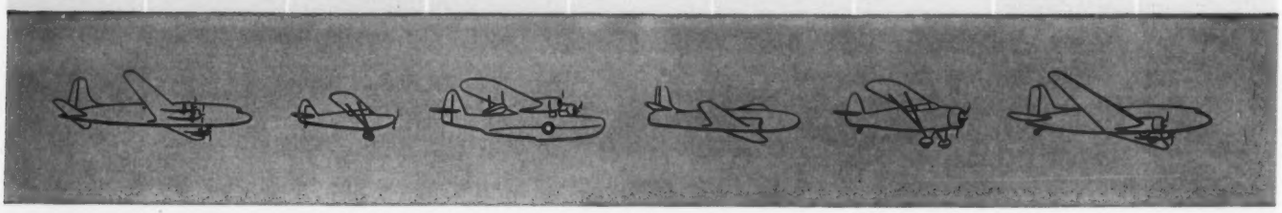

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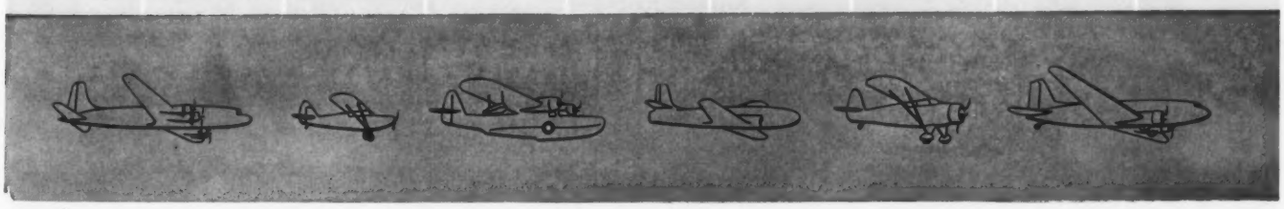

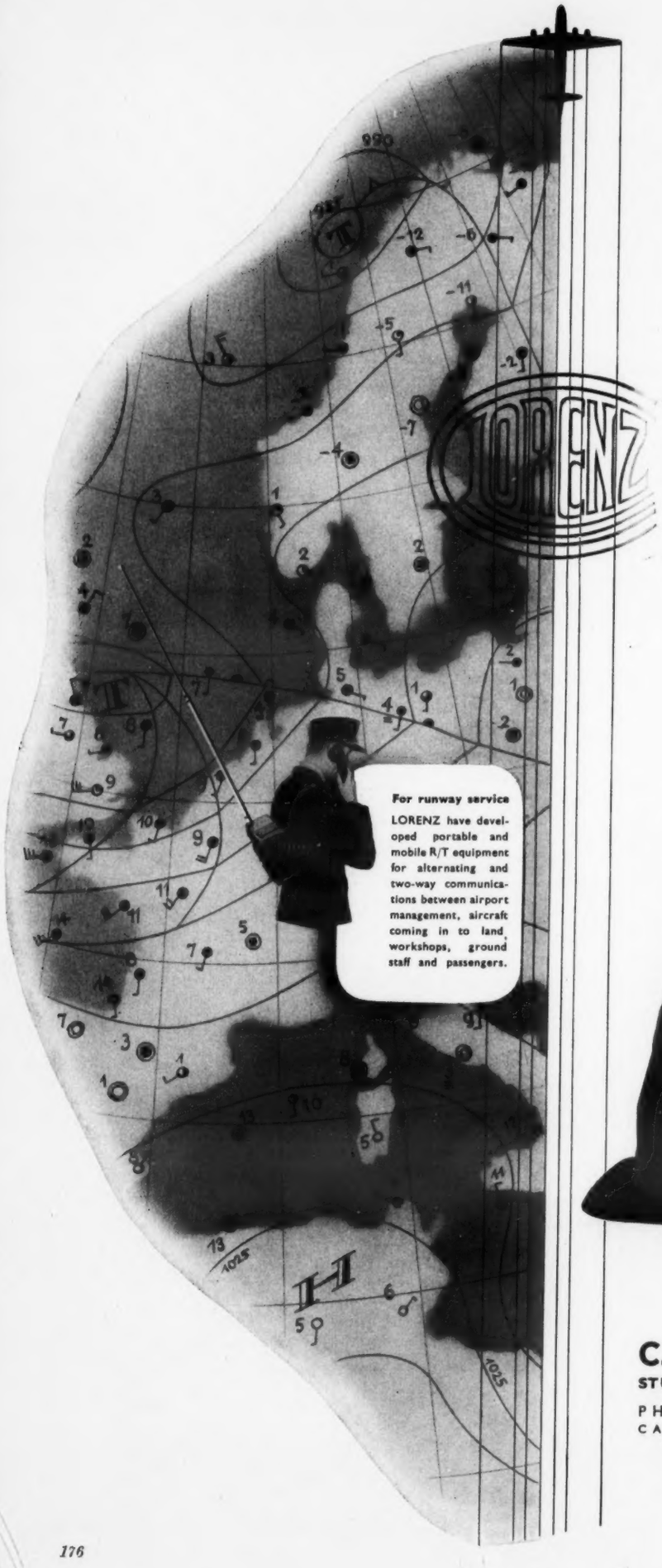

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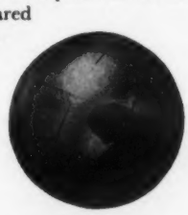

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The Airport—
Symbol of the Modern Age

The present airport issue is a portent of things to come. In future we intend to give a good deal more space to airports than we have done in the past; for what would aviation be without them? A railway without stations! Air transport cannot be efficient nor—need we hint?—an air force hard-hitting without a highly-developed system of airports. The aerodrome has thus become a visible symbol of our present age.

Yesterday it was still shipping which dominated the world transport situation, and experts calculated that a quarter century ago there were roughly 30 so-called world sea ports.* Since then the international importance of many sea-ports has vanished or their place has been taken by others. Whereas yesterday, London was world harbour No. 1, this place is now occupied by New York; whilst Bremen or Kobe, Calcutta, Montevideo or Yokohama came high on the list, they have now fallen back owing to economic developments since the war. Buffalo, once a harbour of importance, has virtually disappeared from shipping charts.

But names such as Hull, Bremen or Singapore are now being replaced by others which yesterday were entirely unknown. Who had heard about Idlewild (New York) or Gander (Newfoundland), Orly (Paris) or even Rhein-Main (Frankfurt) ten years ago? Apart from a few world travellers and perhaps the taxpayer immediately concerned, there is probably not more than a fraction of the public that has any notion of what goes on behind the scenes of a world airport, how many millions of dollars are invested in world airports, and how these investments must always be increasing.

The second World War saw a rapid increase in the range of aircraft and the consequent development of immense installations at isolated spots on the coast of Ireland, Newfoundland or the Azores, with the aid of which, as it is so picturesquely put, a bridge has been thrown over the Atlantic. And just as sea ports in their day brought prosperity to neighbouring towns and countryside, today airports are creating new forms of business, new means of making money and virtually new towns. This was not even dreamt of by the Irish, Newfoundlanders, Portuguese, etc. a generation ago.

Finally, the military value of aerodromes became abundantly clear to the unbiassed newspaper reader early in 1951. General Eisenhower, appointed Supreme Commander of the Atlantic forces, came to Europe. Up to his arrival it was considered vital to include German units in any scheme of European rearmament. Suddenly there was no more talk of German rearmament, but of airfields, and not only of British, French or German. At just about the same time American military experts were "exploring" the Mediterranean coasts and were showing great interest in air bases in Portugal, Spain, Italy, Greece, Turkey and North Africa. To safeguard the Atlantic Powers' southern flank by the rapid provision of large aerodromes seemed to be regarded by American strategists as a matter of urgency.

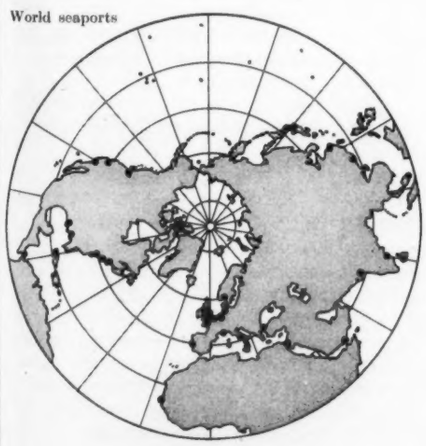
What serves military purposes today may well be useful to civil aviation tomorrow—witness the cases of Gander and Shannon. The network of world airports is still incomplete, the construction of such airports still in its early stages.

Roughly 30 world seaports a generation ago... already nearly 60 world airports today!

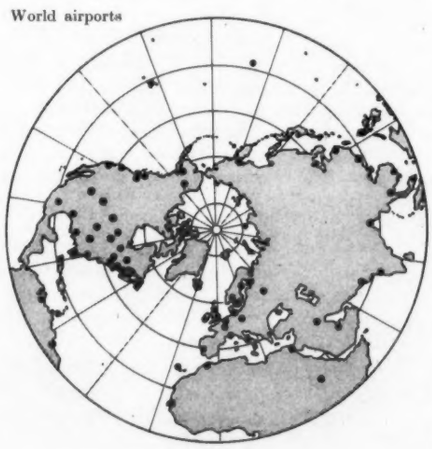
EEH

* Amsterdam, Antwerp, Boston, Bremen, Colombo, Genoa, Gothenburg, Hamburg, Le Havre, Hong-Kong, Hull, Calcutta, Kobe, Constantinople, Copenhagen, Lisbon, Liverpool, London, Marseilles, Montevideo, Newcastle, New York, Philadelphia, Port Said, Rotterdam, San Francisco, Sydney, Singapore, Trieste, Yokohama.

World seaports



World airports



The Ideal Airport

BY RENÉ LEMAIRE,
SECRETARY-GENERAL OF FRENCH CIVIL AVIATION
AND AIR TRANSPORTATION,
CHAIRMAN OF THE SUPREME COUNCIL FOR
AIRPORTS AND AIRWAYS

Introduction

The concept of "the ideal airport" inevitably is subject to constant evolution. When the French Air Ministry was established in 1928, the first problem which M. Albert Caquot, Director-General of Engineering, submitted to the Directorate of Air Bases was that of the ideal aerodrome. Runways did not exist at the time. The idea of the factor of utilization in relation to cross-winds was vague. Our solution was a field in the form of a curvilinear, equilateral triangle.

The concept of an ideal aerodrome is illusory if it is intended to be an insurance against the future. But it is of great value if it is regarded merely as an attempt on the part of a group of researchers engaged in a well-defined series of studies to establish a synthesis. It is in this spirit that I present this article to the reader.

One of the duties of the Supreme Council for Airports and Airways is to formulate opinions on the overall airport plans established by the various civil and military technical services. The experience it has gained in France is the vastest that has been gathered in this field. This experience is set forth in detail in a handbook of technical rules which periodically is brought up to date. The Council also engages in a study of the conditions of air traffic in an area of great traffic density, a problem whose urgency is emphasized by the approaching introduction into service of jet-propelled transport aircraft. Some of the engineering specialists of the Council have indulged in the pleasure of escaping from the concrete opinions which they ordinarily issue on plans and procedures, in order to formulate reasonable speculations, as invited by the title of this article. The efficiency of the installations, the regularity of traffic are the two new tendencies which make the airport an integral part of air transport economics. The following pages will illustrate a number of interesting perspectives.

I wish to thank my collaborators, *Ingénieurs en Chef* Bonnenfant, Eisenmann, *Capitaine* Le Pape of the Air Force and chiefly General Montrelay, Vice-Chairman of the Supreme Council for Airports and Airways, for their help in presenting in this article a few salient points from their studies.

Rlemaire

An aerodrome is the terminal installation utilized by a transport aircraft. Planning an aerodrome raises problems ranging far beyond those of runways and airport buildings to which one would be tempted to reduce it at first glance:

—the aerodrome cannot be dissociated from the overall organization of air services in a given territory and therefore logically forms part of a *general landing facilities scheme ;*

—it cannot be separated from the regulations governing air traffic within a given air space: the aerodrome must therefore be included in the *general air traffic organization ;*

—in the field of air transportation it reflects the functions and the importance of the community in whose vicinity it is located: hence, it must adapt itself closely to the *city pattern.*

I. *The ideal airport and the general airport scheme*

In some cases a single airport can take care of the air transport requirements of an economic centre. More often, however, particularly in the case of communities with more than 500,000 inhabitants, several airports are required, separated either according to destination or according to functions. It is impossible to consider an airport entirely as a self-contained unit. Its functional ties with the other airports helping to provide efficient air service for the same economic centre must be taken into account.

Air transportation involves such distances that planning and operation range far beyond the boundaries of a defined region or a single country.

A regional or national airport scheme as such is not conceivable. It will form a mere component of a vaster system of international importance. In order to establish it, study must be devoted to international requirements and a plan must be worked out for a whole group of territories; subsequently "national" plans must be made for each territory separately; there follow "regional" plans for the various economic units of each territory. Finally, this study will lead to the logical and functional definition of each one of the airports individually, of their reciprocal relationships, their importance and their function.

Going farther than other systems which cover only certain technical characteristics, the French airport classification particularly stresses this functional aspect. It distinguishes four airport classes:

—*Class A*—long-range commercial airport.

—*Class B*—medium-range commercial airport.

—*Class C*—airport for short-range commercial services, and for non-commercial flights ("air tourism").

—*Class D*—airport for light touring and sports aircraft and for "general air work."

This classification lays down for each category of airport certain technical requirements (obstruction clearance, runway length and runway strength) within an upper and a lower limit, which correspond to the needs of aeroplanes of determined categories whose technical characteristics are approximately similar. It thus establishes a relationship between the function of an aerodrome within an air transportation scheme and the geometrical and "mechanical" characteristics of this aerodrome.

Table 1 shows the classification and the principal characteristics of the French airports. The air traffic to be handled by the aerodrome figuring in the general airport scheme is determined by three fundamental elements:

—*its intensity* in terms of the number of aircraft movements or passengers or tons of cargo within a given period;

—*its probable distribution* among the various categories of air transport and the various types of aircraft;

—*its probable growth in time ;* it will be required to handle under normal, safe, regular and economic conditions, the air

CLASSIFICATION AND CHARACTERISTICS OF FRENCH AIRPORTS

Airport Classes	A	B	C	D
Type of traffic	Long-range	Medium-range	Short-range, "tourism"	General air work Private flying Sailplane flying
Runway lengths	10,000 ft. 8,200 ft. 6,900 ft.	6,900 ft. 5,900 ft. 4,900 ft.	4,900 ft. 3,300 ft. 2,600 ft.	2,600 ft. 2,000 ft. 1,300 ft.
Weight of max. performance aircraft	150 short tons	65 short tons	22 short tons	4 short tons
Concrete airways	yes	yes	optional	no
Blind-landing equipment	yes	yes	optional	no
Night-flying equipment	yes	yes	optional	no
Gradient of slopes in approach area	2 %	2 %	3 %	4 %
Air corridors allocated to airport	R 8 miles	R 8 miles	R 2.2 miles	—
Air space of each airport	(1)	(1)		

(1) The air space allocated to an airport must be large enough to permit all final approach and landing manoeuvres to be carried out within its limits.

traffic which will result from the duties allocated to it under the general airport scheme.

An aerodrome must be planned in such a manner as to enable it to handle "maximum performance" aircraft expected to form part of the traffic. On the whole, however, aircraft of lower characteristics will carry the bulk of traffic. Thus, the plans must also ensure optimum service conditions for the most currently used types of aircraft.

An ideal airport should at no time possess excessive equipment and installations: it should always be precisely adapted to the needs of the moment.

Finally, it is essential that in the course of time the characteristics of the airport be adjusted to the progressive growth of traffic and to the gradual evolution of aircraft characteristics towards the anticipated limit, based on the progress of aeronautical engineering.

An airport is not a construction which will remain unchanged from the date of completion. It is an organism which at all times adapts itself to functional requirements as they arise.

Capacity of an airport

Let us consider an aerodrome with a single runway, with equipment of excessive capacity in relation to actual traffic and whose traffic is not subjected to interference by traffic to and from neighbouring airports.

Let us apply the designation *time of accommodation* to the absolute minimum of time separating two aircraft movements. It is a function of the airport equipment, the specialized equipment for landing in bad visibility on the one hand and equipment permitting movements on the ground on the other. The maximum capacity of an aerodrome is determined by the number of *aircraft movements* (landings and take-offs) which it is capable of handling within a given time (per hour, per day, etc.). It is inversely proportional to the time of accommodation: on the basis of a time of accommodation of 2 minutes, the runway will have a maximum hourly capacity of 30 aircraft.

Theoretical capacity of the aerodrome is always inferior to the maximum thus established, since a variety of causes will prevent continuous operation at maximum capacity over a protracted period.

Some of these causes are climate conditions which will preclude the utilization of the single runway, such as cross winds or bad visibility which will not permit adequately safe operation.

Others are due to accidental circumstances, such as runway repairs, etc.

These causes can be expressed in the form of a mathematical probability: the *frequency of utilisation* based on statistical data.

Theoretical capacity is the proportion of theoretical performance to maximum performance.

Actual capacity is still lower than theoretical capacity, for the airport will never be used at maximum capacity throughout the twenty-four hours of the day. And *actual capacity* will therefore be the proportion of actual performance to maximum performance.

Without enlarging runways and apron, the capacity of a single-runway aerodrome can be increased by the following means:

1) if operation is difficult because the field is congested at certain hours, by the reduction in the time of accommodation between two successive aircraft movements: this is a matter of equipment, landing aids and the employment of efficient procedures. The ideal would be to reduce the plan of accommodation to a single minimum value irrespective of good or bad visibility conditions;

2) if the utilization factor is insufficient, by the use of appropriate instrument equipment so as to reduce the unserviceability of the airport in bad visibility;

3) by spreading the traffic evenly over the whole day so as to obtain a regular sequence of aircraft movements; this is a question of traffic regulation.

Once these measures are utilized to the full, the only means of increasing the capacity of the aerodrome is to construct another runway.

Traffic volume

The maximum traffic volume an aerodrome is able to handle is its maximum capacity multiplied by the unit capacity of the "maximum performance" aircraft. It seems that this term will always remain theoretical, for it depends not only upon the unit capacity of the aircraft but also upon their load factor. It is useful for bulk transports (transportation of a given tonnage or number of persons within a given time), but in commercial transport operations it would lead to erroneous conclusions.

Traffic volume could be increased by forcing the aerodrome to specialize so that it would handle only aircraft whose characteristics would approach closely those of the maximum performance aircraft assigned to the particular class of aerodrome.

The runway—Bottleneck for capacity

An aerodrome consists of a chain of distinct but interdependent elements, all of which affect the efficiency of operation.

In order to analyse them, one should examine systematically the succession of operations effected or undergone by the aircraft and by the "traffic units" (passengers or cargo). Table 2 breaks down this succession of events and shows up the mechanism of the operation.

Smoothness of operation and reasonably

OPERATIONS OF AN AIRPORT

1. AIRCRAFT Arrival Departure		
Landing	→	Runway
Ground Movements	→	Taxiways
Traffic Operations	Unloading, Servicing, Control, Loading →	Apron
Parking	(if required) →	Parking areas
Maintenance	(if required) →	Maintenance areas
Ground Movements	→	Taxiways
Take-off	→	Runways

2. PASSENGERS (Arrivals)		
Deplaning	→	Apron
Formalities	(health, police, Customs) →	Passenger terminal
Transport to city	→	Bus (highway), helicopter
Arrival in City	(Pick-up of baggage) →	City terminal

3. CARGO (Arrival)		
Unloading	→	Apron
Warehousing	→	Motor vans
Formalities	Checking, Customs, removal →	Cargo terminal sheds, warehouses.
City delivery	→	Motor vans (highway)

low cost for services rendered must be aimed at as regards both aircraft and "traffic units." These needs, which are affected by the equipment on the ground, are met by concentrated efforts to *reduce waste of time to a minimum*. However, it is the runway which determines the capacity of the airport, and it also is the element most difficult to influence and most costly to improve. From this we derive the following fundamental rule for the ground facilities as a whole: *the capacity of all elements of airport equipment must be adjusted to the basic capacity of the runways*. In the ideal airport, the only bottleneck will be the runways, and all the other elements will be *precisely adjusted* so as to handle in a minimum of time the traffic volume resulting from the useful capacity of the runways, at the same time providing the standards of comfort and ease to which users are entitled.

Let us suppose that actual traffic volume is equal to the maximum which the runway is capable of handling.

a) If the maximum capacity of a runway amounts to 40 movements per hour (take-offs and landings in equal proportions over a protracted period), the taxi-ways must be able to evacuate 40 aircraft per hour. It would be useless to provide for a greater capacity; but it must be borne in mind that at certain periods landings and take-offs will be made without discontinuity (for example, 40 consecutive landings without intervening take-offs, or vice-versa). If is therefore necessary to provide maximum ease for aircraft moving about on the ground:

—shortest taxi distances between apron and runways;

—adequate radius for turns;

—no intersecting taxiways and runways;

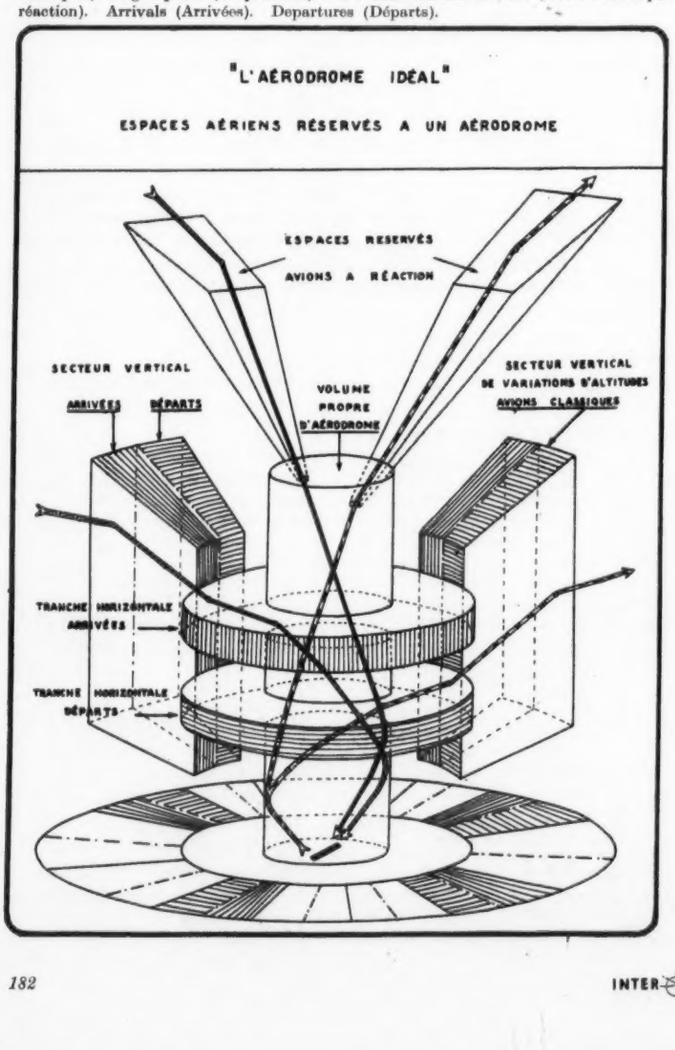
—no intersections of runways in operation.

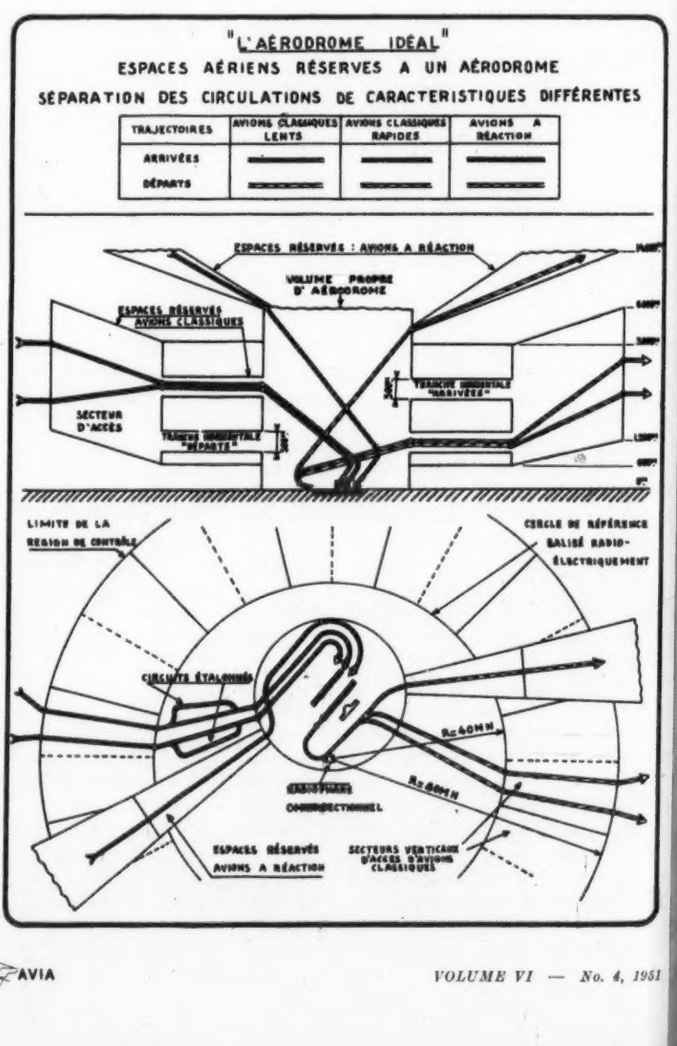
b) Arriving and departing passengers representing the normal traffic volume furnished by 40 aircraft movements per hour must be able to pass through the formalities without hindrance and in a minimum of time. This requirement determines not only the architectural volume of the aerodrome and the liaison between its various working parts, but also the working procedures of the public control authorities (customs, health service, police) and the services responsible for the rapid reception and removal of passengers and their luggage. Passengers must be carried rapidly and comfortably to the city centre by a special motor road. This simultaneously raises a problem of road construction and one of motor bus operation.

The multitude of factors which go to make up the ideal airport have thus been outlined and a guide provided to their relative importance, starting from the fundamental bottleneck, the runways.

Figs. 1 and 2: The air spaces reserved for an airport are defined so as to correspond to the characteristics of the aircraft using it. These figures show the "ideal" segregation according to types of traffic. They are composed of: (1) an air space forming an integral part of the airport; (2) air zones reserved for traffic to and from the airport, with separate zones for jet-propelled and conventional piston-engined aircraft. — The spaces reserved for conventional aircraft comprise vertical sectors and horizontal zones; inside the vertical sectors aircraft will move from their cruising levels to the height of the horizontal zones. The latter divide arrivals and departures. The arrival zone contains standard circuits (diagrammatically shown in fig. 2) which can be used as stacking circuits. Control over arriving aircraft begins in the vertical approach sectors and is exercised by the airport of destination.

Space reserved for jet aircraft (Espaces réservés avions à réaction). Vertical sector, arrival and departure (Secteur vertical, arrivées, départs). Air space integral with airport (Volume propre d'aérodrome). Vertical sector for altitude changes for conventional aircraft (Secteur vertical de variations d'altitude avions classiques). Horizontal zone—arrivals (Tranche horizontale arrivées). Horizontal zone—departures (Tranche horizontale départs). Space reserved for jet aircraft (Espaces réservés aux avions à réaction). Air space integral with airport (Volume propre d'aérodrome). Space reserved for conventional aircarft (Espaces réservés avions classiques). Horizontal zone, arrivals (Tranche horizontale « arrivées »). Approach sector (Secteur d'accès). Horizontal zone, departures (Tranche horizontale « départs »). Boundary of control area (Limite de la région de contrôle). Circle marked by radio (Cercle de référence balisé radioélectriquement). Standard circuits (Circuits étalonnés). Omnirange (Radiophare omnidirectionnel). Space reserved for jet aircraft (Espaces réservés avions à réaction). Vertical approach sectors for conventional aircraft (Secteurs verticaux d'accès avions classiques). Flight paths (Trajectoires). Slow conventional aircraft (Avions classiques lents). Fast conventional aircraft (Avions classiques rapides). Jet Aircraft (Avions à réaction). Arrivals (Arrivées). Departures (Départs).





II. *The ideal airport and air traffic control*

The maximum capacity of a runway is inversely proportional to the "time of accommodation": the latter depends, as we have seen, on the overall equipment of the airport; it can differ also for arrivals and for departures and according to the time of day. On a specialized landing runway, successive arrivals of aircraft in the approach zone must be timed to correspond to the time of accommodation for the runway in question.

Hence, the concept of an ideal aerodrome is futile unless it is established in direct connection with an equally ideal air traffic control organization.

No detailed study of this organization is required to make it clear that the objects of traffic control will be to safeguard the traffic for its own airport and separate in the air space the traffic belonging to neighbouring aerodromes.

It would be useful too to allocate an integral, well-defined air space to each airport. Thus, the conception of the aerodrome begins to extend: it now comprises not only runways, aprons and ground installations, but also a definite air space with which it is indissolubly linked. The diagrams of Figs. 1, 2, and 3 illustrate this idea of an air space forming an integral part of an aerodrome.

The distribution of these "air spaces" is extremely intricate when airports are numerous and closely spaced. From this point of view the ideal aerodrome should be remote from any others. In practice, however, one rarely has a choice of sites, for the local interests which it is the aerodrome's duty to serve compel its location within a certain radius and often require the construction of several airports. The resulting compromise will respect the imperative requirements of air traffic, with the effect that neighbouring airports will become interdependent, notably as regards the layout of the principal runways.

To sum up: a definite air space must be allocated to each airport, and the ideal airport must be free from interference from traffic to or from neighbouring airports.

The engineering talent which has been devoted to air traffic control has produced an imposing array of control equipment on the ground. The different components of the apparatus charged with controlling air traffic of one aerodrome must be considered as the property of this particular aerodrome[1]. Their operation therefore is the responsibility of the airport manager, subject to the necessary co-ordination which, in regions where several neighbouring aerodromes are in existence, will be effected at the highest level.

The ideal airport will control its own air traffic by its own means. This is one of the prerequisites for a theoretically high degree of efficiency.

Let us now consider the air traffic of one aerodrome as a whole. Actual capacity could be close to theoretical capacity if all aircraft appeared on the runway approach in an unending, ordered sequence. The problem of the control of arrivals consists of converting an initially haphazard distribution of aircraft in space into an "ordered sequence" on the runway approach. This state, which it is not possible to attain in practice, would require perfect control and the latter, in turn, a control action extending without interruption over all phases of flight and, prior to take-off, over the operating schedules of the aircraft.

The airport of destination can obviously not be charged with this overall control, but actual capacity would gain considerably if it could be effected. It seems that something could be done at the two extremities of the operation:

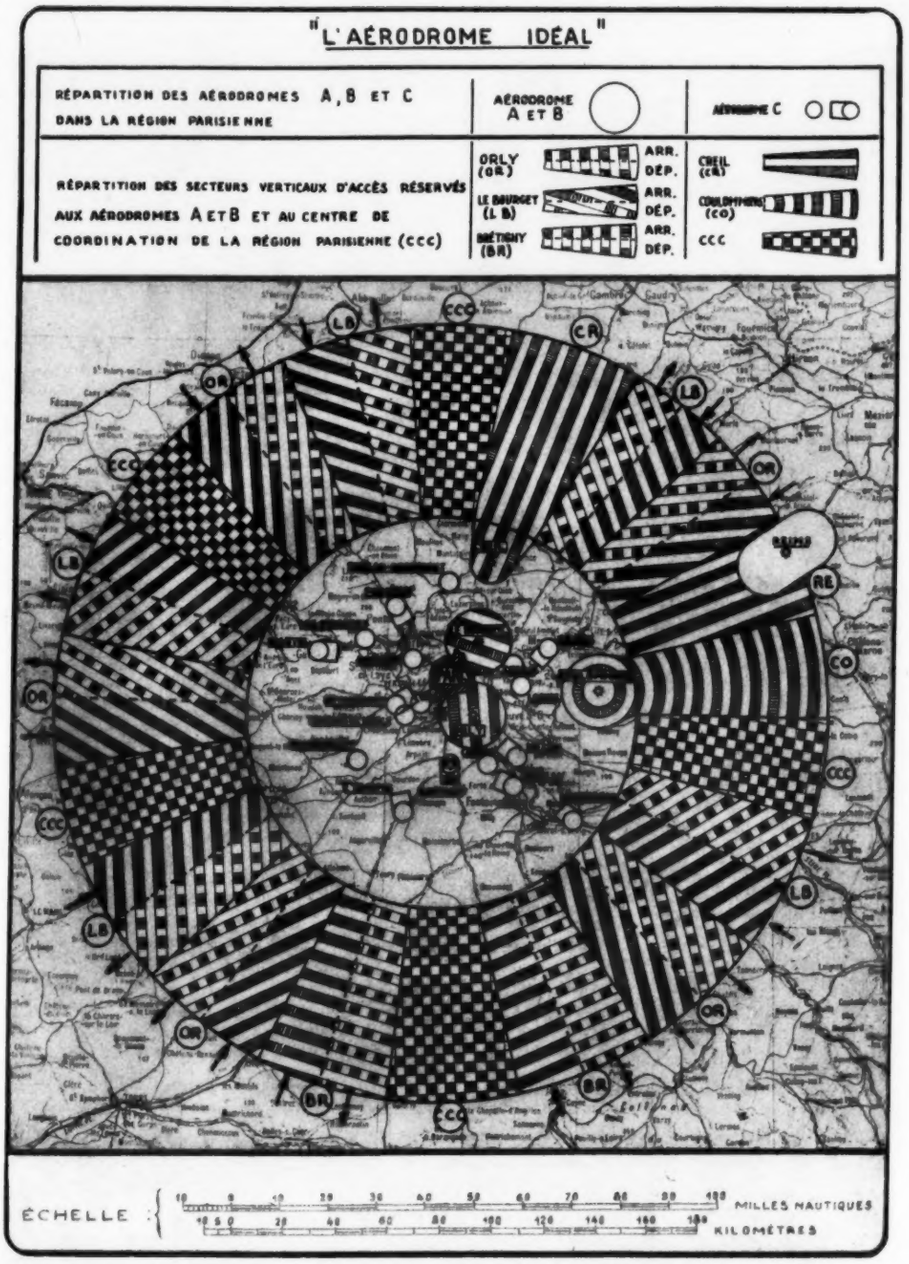


Fig. 3 : Application to Paris region of principles shown diagrammatically in Figs. 1 and 2 : The outer circle marks the boundary of the control area, the inner circle separates the vertical sectors from the horizontal zones ; it is limited by radio markers. — The airports, classified according to characteristics as shown in Table 1, are illustrated with their integral air spaces. Class D airfields are not shown. Certain "Class C, equipped" airports are equipped for bad weather operations (approach only). — Each A or B Class airport has at its disposal, in the annular space, certain reserved sectors ; these sectors are allocated to it by the Regional Air Traffic Control Centre, which functions as a centre of regional operational co-ordination. The Centre in addition has at its disposal a number of vertical sectors (marked CCC) for use by aircraft flying over the region without landing. — Traffic to and from C and D Class fields operates at heights between ground level and 600 metres (level of the lowest horizontal zone).
Location of A, B and C Airports in the Paris region (Répartition des aérodromes A, B et C dans la région parisienne), A and B Airports (Aérodromes A et B), "C equipped" Airport (Aérodrome C équipé), C Airport (Aérodrome C), Distribution of vertical approach sectors reserved for A and B Airports and for the Paris Regional Air Traffic Control Centre (CCC) (Répartition des secteurs verticaux d'accès réservés aux aérodromes A et B et au centre de coordination de la région parisienne (CCC).

[1] Long range instruments covering wide areas, such as long-distance surveillance radar, may function for the benefit of several airports. Their work must depend upon a functional command covering an entire region.

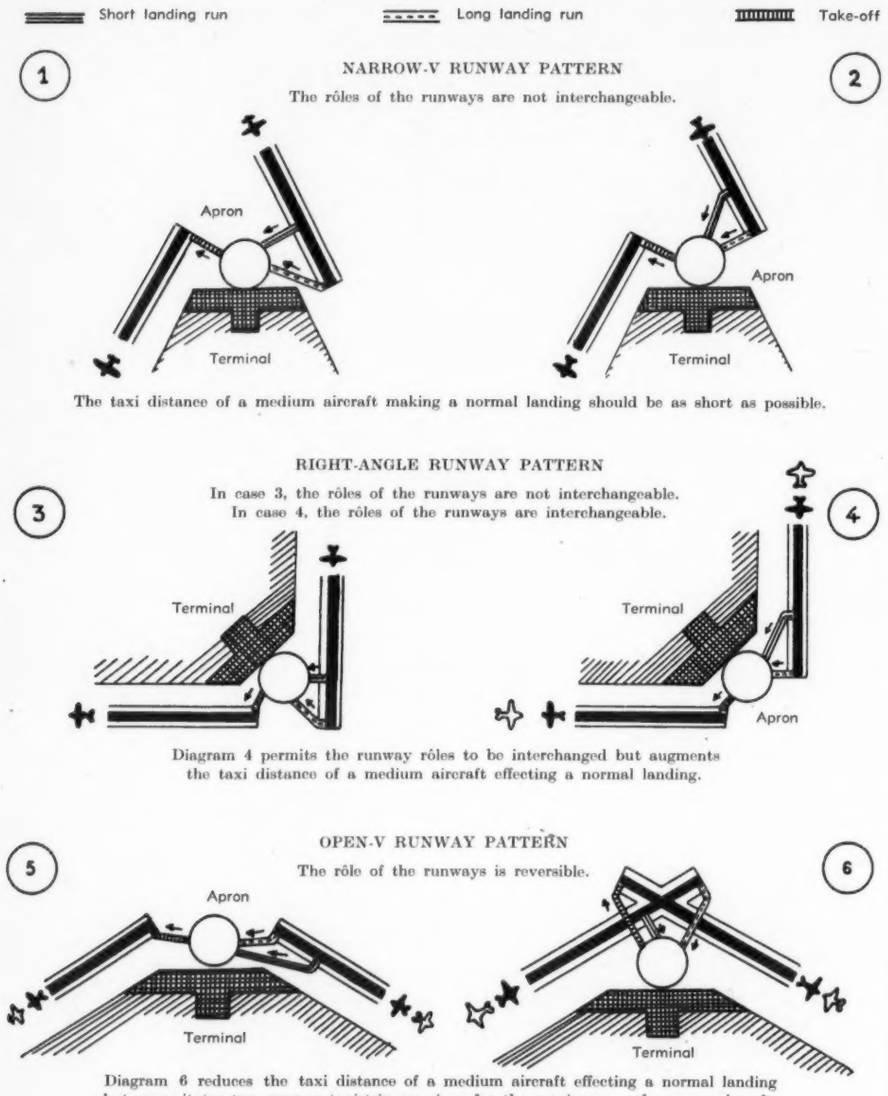

Short landing run
Long landing run
Take-off
1
NARROW-V RUNWAY PATTERN
The rôles of the runways are not interchangeable.
2
Apron
Terminal
Apron
Terminal
The taxi distance of a medium aircraft making a normal landing should be as short as possible.
RIGHT-ANGLE RUNWAY PATTERN
In case 3, the rôles of the runways are not interchangeable.
In case 4, the rôles of the runways are interchangeable.
3
4
Terminal
Terminal
Apron
Diagram 4 permits the runway rôles to be interchanged but augments the taxi distance of a medium aircraft effecting a normal landing.
OPEN-V RUNWAY PATTERN
The rôle of the runways is reversible.
5
6
Apron
Terminal
Terminal
Diagram 6 reduces the taxi distance of a medium aircraft effecting a normal landing but necessitates two runway-taxistrip crossings for the maximum performance aircraft.

Fig. 4 : Simultaneous operation of runways and necessary compromise. In the case of an airport with two non-parallel runways, the runway pattern affects capacity and economic efficiency of the airport.

—a carefully thought-out "inter-aerodrome" (international) organization would contribute to the establishment of schedules which within certain limits would make the hours of departure dependent on the most convenient hours of arrival ;

—in the last phase of the flight (which would start as far away from the airport of destination as feasible with existing air-ground communications equipment and which would be assured of precise position indications), the flight would be made an integral part of the traffic belonging to the airport of destination and controlled by a single control point exercising its authority without change-over right up to the approach to the runway. It would be up to the airport of destination to control all air traffic belonging to it, with the exception of unexpected traffic (*i.e.*, traffic of which the airport controller has not sufficient warning and which must be dealt with by special measures).

Finally, we shall cite another possible effect of air traffic on the organization of the airport, namely, one which refers to the use of *parallel runways :* the addition of a new runway will have its full effect only if it is utilizable at the same time as the whole runway system. Just as one will be led to allocate to each airport a determined air space, one might be forced to establish "single airways" in this space; these would be determined flight paths corresponding, for example, to the technical characteristics of the aircraft using them: higher or lower level speeds, larger or smaller angles of descent or climb. It may even become necessary to have these specialized flight paths terminate at separate, parallel runways, notably in order to facilitate the use of distinctive final approach procedures. Fig. 5 illustrates this specialization of "single airways" within the air space reserved for one aerodrome.

III. *The ideal airport and the city pattern*

Constructing an airport means fitting it into the city pattern of the community it serves. Here we shall meet two factors previously encountered which determine the operational value of the airport: *obstruction clearance* and *frequency of utilization*; we shall have to introduce another factor, *accessibility by surface transport*, which has a decisive influence on the economic value of the airport. The optimum solution will be a compromise between the three requirements.

Obstruction clearance is of capital importance in the case of a large airport of Class A. The characteristics of trans-oceanic aircraft require unusual sites in order to meet the exceptional clearance requirements. Since the beginning of aviation they have resulted in a progressive move of airports from the immediate proximity of large towns to remoter sites better suited to satisfy the requirements imposed by speed and wing loadings of large aircraft.

For airports of Class B the relative need for obstruction clearance is slightly less marked. The economic future of an airport depends in a large degree upon its situation with regard to its *hinterland* and upon the ease and rapidity of communications between airport and hinterland.

For aerodromes of Classes C and D, the problems of obstruction clearance are generally much more readily solved; they are more or less of a secondary nature, and in most cases they can be met in the immediate proximity of communities.

Considerations of *frequency of utilization* are of paramount importance for Class A airports. The commercial value of flying equipment and the imperative conditions of regularity of service would lead trans-oceanic air carriers to abandon airports with a record of frequent unserviceability.

For Class B airports the problem of frequency of utilization is much less pressing. Ease of communication with the hinterland and saving in initial cost may result in preference being giving to a cheaper and less remote vicinity, in spite of the consequent lower utilization factor.

For fields of Classes C and D, frequency of utilization is even more a secondary consideration. The user will be able to put up with a certain degree of irregularity; accessibility, on the other hand, assumes preponderant importance.

Considerations of accessibility by surface transport differ according to whether the greater part of the traffic is in transit or whether it originates at or is destined for the community served. In the first case they carry small weight; in the second, they are predominant.

High speed is one of the decisive advantages of air transportation, and "airport-to-airport" travelling time is less important than the total "city centre-to-city centre" time. The real problem therefore is not to move the airport as close to the city as possible or to connect it with a railway network, but to link it directly to the business centre by a wide and unobstructed arterial highway. Such a highway would thus also be "specialised" and enable passenger buses and cargo trucks to run very high cruising speeds without risk of being held up.

The city terminal, the point of origin of this special highway, should be located as

centrally as possible and linked to the networks of urban and suburban transport.

It is foreseeable that in the near future these terminal communications between airport and city centre will be effected by helicopter.

IV. *The practical point of view*

The above considerations in the quest for the ideal airport would remain quite theoretical without a study of the financial problems which, like in any other question of equipment and transportation, dominate the problem. They present themselves in two forms:

—initial cost of construction and equipment,

—annual expenditure for operation, maintenance, interest and depreciation.

As regards buildings and runways, capital investments comprise a share which is in direct proportion to the traffic volume (surface of landing area, size of airport buildings) and a share which is not.

Runways and taxistrips reflect increasing traffic only in abrupt stages, each of which marks the attainment of another saturation point.

For this type of work variations in cost per traffic unit from one airport to another are insignificant.

On the other hand, the installations not proportional to traffic volume run the risk of becoming investments of extreme variability per traffic unit, ranging from an optimum value corresponding to the effective saturation of the runway to a very high figure reflecting a very low runway utilization.

This introduces a new concept which we might call "*the cost of service*" and which would be determined by dividing the annual financial charges of the aerodrome by the number of aircraft movements.

In addition to the *minimum cost of service* calculated under conditions of saturation, consideration must be given to the *actual cost of service*, which corresponds to the effective operation of the aerodrome.

To attain the minimum cost of service three conditions are essential:

1) *Regardless of its design, the aerodrome must be used in such a manner as to approach the saturation level of its runways as closely as possible.* This might lead to a concentration of the major share of traffic available at a given time on certain well-equipped airports.

2) *Airport features which vary stage by stage must not be enlarged before traffic reaches saturation level.* It is useless to build two parallel runways if one is sufficient to deal with all available traffic.

3) From an economic point of view, there is little use in increasing the number of airports in a given region; construction of new airports should be envisaged *only when existing facilities have reached saturation point*[2].

Of all basic works at an airport, the most expensive are certainly the traffic installations, such as apron and hardstandings, runways, taxiways, radio navigation equipment and blind landing aids. A *Class A* runway today costs about a thousand million French francs, and the size of the capital investment is roughly proportional to the number of runways.

4) Finally, if the question is regarded from the point of view of the air carrier and if the cost of service rendered by the airport is to be reduced to a minimum, it will be necessary in *addition* to improve the control of air traffic in order to eliminate waiting and stacking periods imposed on aircraft prior to landing. This waiting is an expensive item for the carrier: it can be reduced only by a better distribution of arrivals, hence by strict *air traffic control.*

V. *Limitation of number of runways*

The endeavour to cut the cost of service to a minimum profoundly affects the relatively simple conclusions which might be reached in purely technical studies of airport construction and air traffic control.

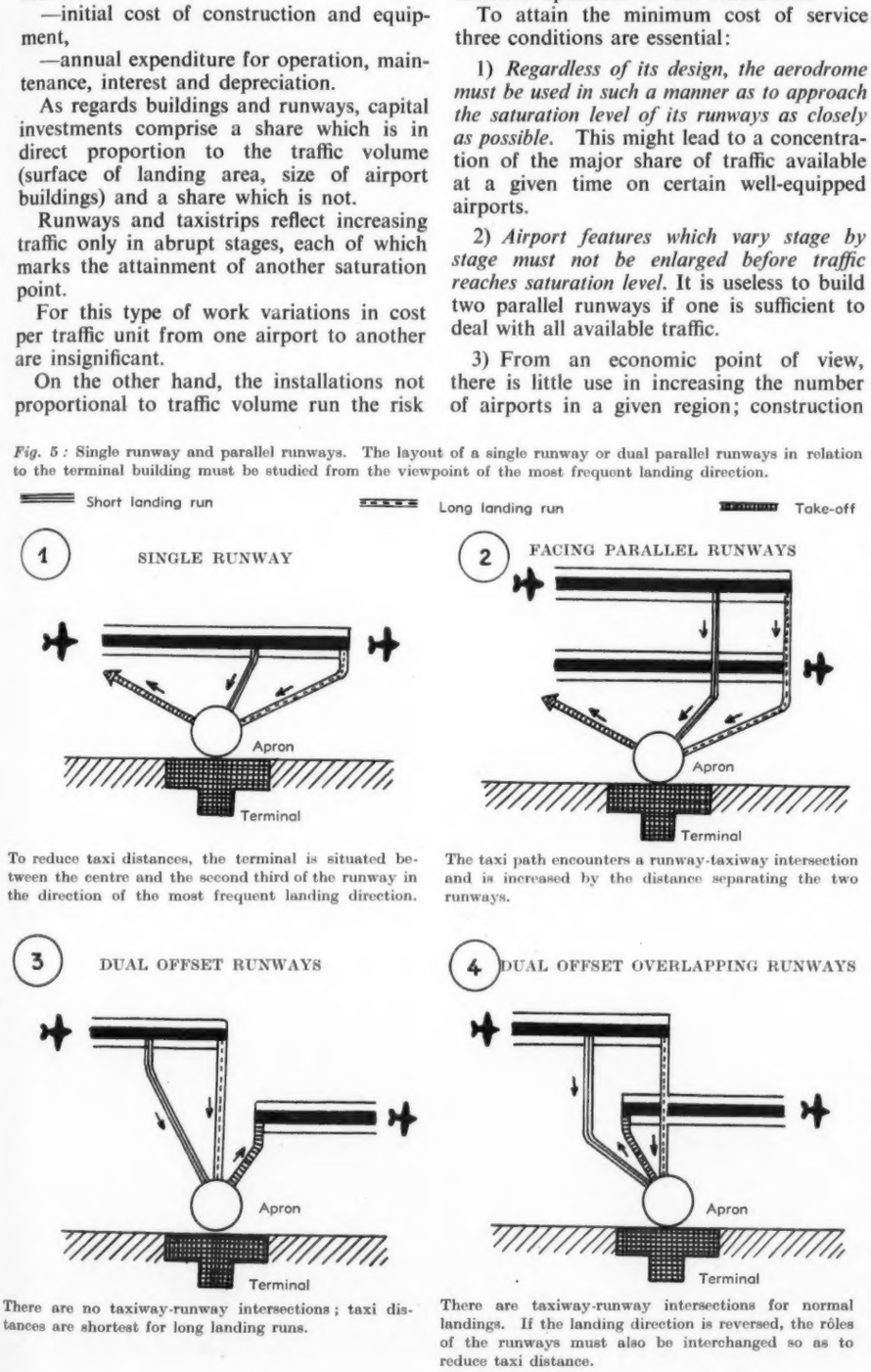
It is especially difficult to reconcile technical standards and profit-making considerations at the ideal airport. However, the real problem is not to design or build an ideal airport but to conceive and construct a *practical airport*, which for a minimum cost of service also closely approaches the concept of the ideal airport from the technical point of view.

A compromise is always necessary between opposing requirements, particularly in the obvious contradiction between the attempt to obtain an airport utilisation factor as close as possible to 100% and the endeavour to keep the number of runways to a minimum.

It is very rare to attain the ideal frequency of utilisation of 100% with a single runway. In order to reach it, two or even three runways are required. In many cases, the gain in the utilisation factor from an additional runway is small or even negligible. It is an art to know when an end must be put to efforts to improve this factor.

For very large airports there exists a means of improving the utilization factor without greatly increasing the actual cost of service: this is to lay out the runways

Fig. 5 : Single runway and parallel runways. The layout of a single runway or dual parallel runways in relation to the terminal building must be studied from the viewpoint of the most frequent landing direction.



To reduce taxi distances, the terminal is situated between the centre and the second third of the runway in the direction of the most frequent landing direction.

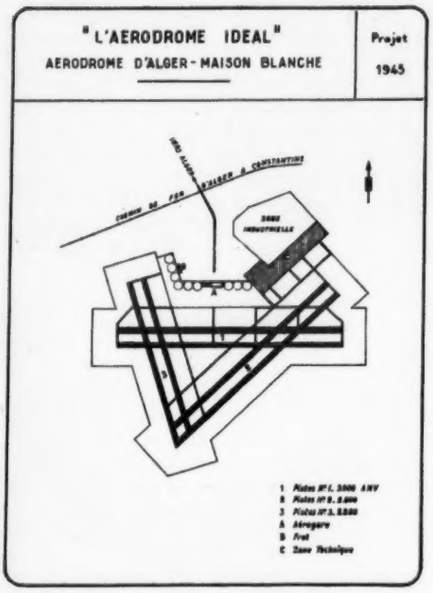
The taxi path encounters a runway-taxiway intersection and is increased by the distance separating the two runways.

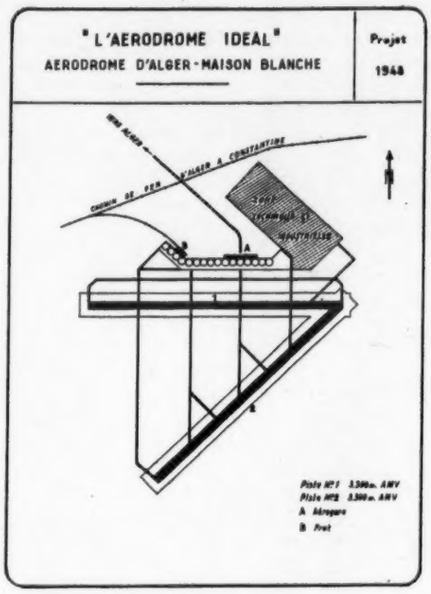
There are no taxiway-runway intersections; taxi distances are shortest for long landing runs.

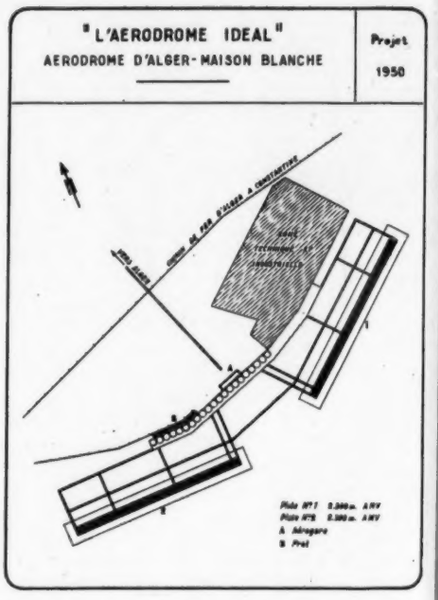
There are taxiway-runway intersections for normal landings. If the landing direction is reversed, the rôles of the runways must also be interchanged so as to reduce taxi distance.

[2] Other considerations may play a role, particularly in regions of high traffic density. Thus, the Paris region had to be equipped with two major airports, *Orly* (Class A) and *Le Bourget* (Class B), although it will be a long time before the long and medium range traffic to and from this region will be sufficient to saturate even one of the two airports operated at maximum capacity. It was considered wise to concentrate all passenger services at Orly to facilitate the linking of long distance routes (trans-Atlantic and trans-Continental) with the French and European networks and to specialize the operation of Le Bourget (which can also handle local traffic) in the handling of cargo.

The same idea of specialization has been applied to other fields by the systematic transfer to C or D class aerodromes of all light traffic and also by concentrating military aircraft, experimental aircraft, schools and training centres on specialized aerodromes and less busy airports.







Figs. 6 to 8 : Algiers-Maison Blanche Airport : Three stages in the simplification of the project. Fig. 8 shows the Open-V pattern now being built.

Fig. 6 (Translation of Terms) :
(1) Runways No. 1 9900 ft. (A) Terminal
(2) Runways No. 2 8900 ft. (B) Cargo Terminal
(3) Runways No. 3 7200 ft. (C) Engineering Area

Fig. 7 (Translation of Terms) :
Runway No. 1 10,800 ft. (Instrument)
Runway No. 2 10,800 ft.
(A) Terminal (B) Cargo Terminal

Fig. 8 (Translation of Terms) :
Runway No. 1 7,500 ft. (Instrument)
Runway No. 2 7,500 ft. (Instrument)
(A) Terminal (B) Cargo Terminal

in different directions so as to enable them to operate separately and independently of each other in no-wind or slight wind conditions. In this manner the theoretical capacity of the aerodrome can be doubled. On the other hand, during brief periods of unfavourable cross winds, operations would be reduced to a single runway. This gives rise to a new idea: since considerations of frequency of utilization seem to lead to a multiplication of the number of independent runways, one will have to establish a pattern under which all runways could be operated simultaneously. This presupposes that neither they nor the flight paths of the aircraft using them intersect.

Figs. 4 and 5 show, in a single case, certain layouts which would meet this condition, and others which would not.

Particular mention should be made of runway patterns *featuring a very open V*, of the type which will be constructed at Algiers-Maison Blanche Airport (Figs. 6, 7 and 8), as compared with the classical diagram of two parallel runways offset longitudinally and laterally. This plan, too, would have the advantage of improving the *overall* utilization factor by permitting the temporary operation of one runway at times when excessive cross wind prevents the operation of the other. This is not possible in the classical design of two parallel runways.

VI. *Conclusions*

Let us quickly recapitulate the progress our concepts have made since preliminary studies of overall airport schemes were initiated directly after the war. As traffic developed and projects succeeded each other, the number of airports deemed necessary for a particular region was continually reduced. Furthermore, in each airport, particularly in the principal ones, the number of required runways was reduced. On the other hand, the means of air traffic control and air navigation have been improved (navigation aids, landing aids, etc.).

As a whole, present plans provide for a smaller number of installations, but each one of them performs a greater amount of work and therefore justifies a greater initial cost. On balance, however, a substantial reduction in capital investment and overall operating costs has certainly been achieved.

While economies evidently can be effected by concentrating air traffic on a few intensively operated airports and at each of them on a small number of runways, the fear has been expressed that this evolution would run counter to the interests of operational safety. This safety depends largely upon the wide dispersion of aircraft in the air space, *i.e.* on their separation in altitude and distance.

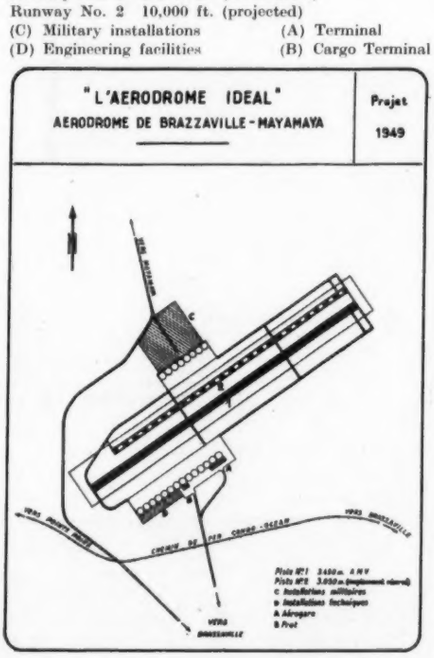
Thus it is technical evolution itself which graphically emphasises the *necessity of regulating air traffic*, in other words, of dividing the air space in which aircraft concentrate into separate zones allocated to specific airports or even to specific airways. Such a division would create air sectors in which the manoeuvres of aircraft or flight trajectories would be very strictly supervised and directed since traffic would be extremely intense. Strict air traffic supervision is becoming equally indispensable to safety, because aircraft must be kept within their narrow zones , and because the ruinous stacking periods must be avoided.

Thus, if ground facilities of maximum economy and operating efficiency are to be established, it will be essential to devote increasing attention to the organization and control of air traffic.

As a growing wealth of experience is gathered, one fundamental fact becomes increasingly apparent, namely, the close interdependence between problems of airport design and construction on the one hand and problems of air traffic control on the other. This fact will have a decisive influence both on our studies and on the realization of our projects.

Fig. 9 : Brazzaville-Mayamaya Airport : Rational layout of ground installations. A single runway is adequate, but the project provides for the addition of a second, parallel runway. Taxi distances are as short as possible for aircraft using the principal runway.

Translation of Terms :
Runway No. 1 11,300 ft. (Instrument)
Runway No. 2 10,000 ft. (projected)
(C) Military installations (A) Terminal
(D) Engineering facilities (B) Cargo Terminal



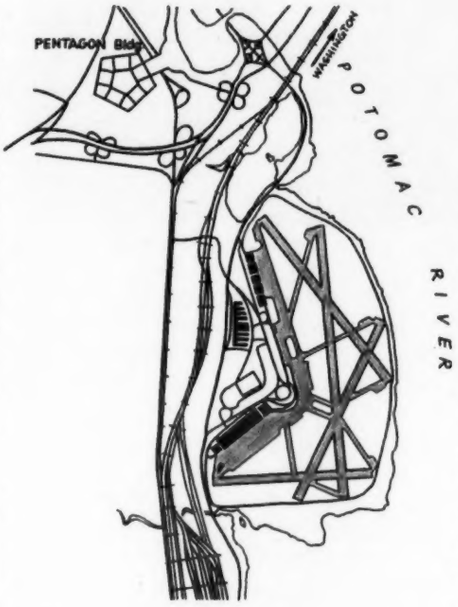
The Life of a Traffic Controller

His Work at Washington National Airport

BY CHRIS ROBERTS, WASHINGTON

The fates of dozens of the world's most important statesmen have been held, at least for periods measured in minutes, in the hands of a tiny group of completely unknown young men. All of the top officials of the United States government regularly entrust their lives to these men whom they have never met, nor even seen. One of the best customers of this life-saving service is the President of the United States, easily the "flyingest" President in the history of the nation. These unseen custodians of the world's great are the Airport Traffic Controllers at National Airport, Washington, D.C.

As one of the world's busiest airports, the job of controlling traffic at National Airport is an extremely complex one requiring many hands, many eyes and many expert and correct decisions. During the calendar year 1950 a total of 6,325 military, 116,398 scheduled airline, 20,682 itinerant and 5,343 local aircraft landings and take-offs were made at National Airport, a grand total of 148,748 traffic movements. Since it requires an average of four contacts for landing and six contacts for take off, and since each contact averages about 25 words from the tower, the traffic controllers at National Airport delivered roughly 18 million words to pilots during 1950.



With this size job to be done, there is little wonder that the airport employs a total of 31 traffic controllers. While this may seem a huge staff for so simple a job, it must be borne in mind, firstly, that traffic controlling is a 24-hours-a-day job and that means three equal shifts around the clock. Secondly, the work week is only 40 hours—yet the tower must be in operation seven full days out of the week, so that the controllers must be further staggered so that each only works 40 hours. Thus, these requirements reduce to seven the actual number of operators on duty during a single shift.

Only chaos would result with seven men talking into seven different microphones at the same time. The seven men on duty on a tower shift at National Airport therefore are each assigned a specific job to do. One man is a full time Ground Controller, who is charged with surface movements on the airport: planes taxiing in to a parking position, planes moving out to the take-off position. A second man handles only Approach Control, that region in a plane's flight between his clearance to enter the Traffic Pattern and his touch-down on the runway. A third man specializes in local traffic, a fourth in initial contacts upon entering the airport Control Zone. A fifth man is assigned to Airport Surveillance Radar and a sixth to Precision Approach Radar. The seventh man is the Senior Controller on duty and heads the shift.

Washington National Airport is unique in the United States in that it is the only civil airport owned and operated by the United States Government. It is administered directly by the Civil Aeronautics Administration and, because of this, it has long served as a "model" airport for the rest of the country. For this reason,

The terminal building of Washington National Airport. The tower occupies a commanding position.

CAA Ground Controller at Washington National. Note the runway diagram on the control table.

its personnel bear an extra responsibility for skill and exactness in their work, much as the local police force bears in insuring honesty and efficiency in the operation of the local police station! The not-infrequent tragic accidents that have occurred at National Airport have always created a hue and cry across the nation's other airports such as: "If the CAA can't operate its own airport, how can it tell us how to operate ours!" It is this constant glare of criticism that bears heavily on National Airport personnel, and nowhere more heavily than on its Traffic Controllers, who are the bone and sinews of all airport operations.

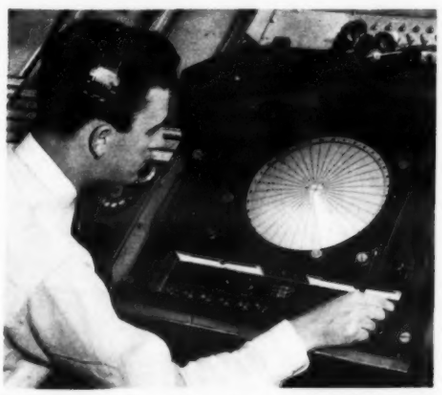
Chief Air Traffic Controller is Mr. Stan Seltzer, who is in over-all command of the 31-man team. Because of the unique status of National Airport, he is in many respects chief controller of the CAA, and in few more capable hands could this tremendous responsibility be placed. Assisting him in charge of the shifts are Senior Air Traffic Controllers George Ashley, Paul Moore, Robert Moore, Frank Sanchez and Robert Boebel. Easily the most kidded of these is Mr. Boebel, whose name is pronounced "Babel" and is linked with the word "tower" in a variety of ways depending entirely on the imagination of the jokester.

Washington National Airport's Traffic Control Centre: airport surveillance radar and communicators at work.

It is well to point out here that in the United States air traffic is controlled by two separate groups, depending upon the location of the aircraft. Air Route Traffic Control handles communications with planes en route, such as position reports from check points, requests for changes in altitude, notification of changes in estimated time of arrival, etc. The ARTC Center is located in the Terminal Building and is not a part of the Control Tower operation. A measure of the job handled by this group is seen in a simple list of the radio frequencies and communications functions they must perform simultaneously: 278 megacycles is the tower communication frequency, 332 mc is the Washington Range frequency, 109.9 mc is for local work, 121.9 mc is the GCA communication frequency, 119.1 mc is VFR local (aircraft operating under Visual Flight Rules only), 118.1 mc is for international flights, 118.3 mc is the Approach Control frequency, 137.88 mc is the USAF communication frequency, 134.64 mc is Navy communication frequency and 121.5 is the military emergency frequency. This is a graphic indication of the communications job undertaken every hour of the day at Washington National Airport.

Students should think very carefully before undertaking training to become air traffic controllers, yet this is one of the most popular ambitions among air-minded American youth (next to piloting, of course!). While it would seem to the layman that the exacting work would require a controller to be actually on the "mike" for only a limited time of, say, one hour, followed by a rest period, the actual fact is that the traffic controller is a full-time operator and it is not unusual during a busy shift for him to be on his feet working the mike for his full eight hours.

Another misconception is that there is little to do on clear, sunny days but that the controller must sweat blood of anxiety and frustration during very bad weather. Washington National controllers dispel this myth by revealing that in clear weather everybody and his brother is out flying, whereas in bad weather the number of traffic movements is reduced substantially.



Close-up of an airport surveillance radar scope.

Thus, in actual fact, the work load is more or less self-adjusting: more planes in the air in good weather with less time required for each; fewer planes in the air in bad weather with considerably more time required to handle each of them.

Exactly how much work is involved for each airplane? A typical clear weather incoming flight control begins with the airplane calling in from a distance of five or ten miles and requesting clearance to enter the traffic pattern. This enquiry is answered by giving the plane such clearance and simultaneously informing him of the runway in use and the wind direction and velocity.

After the plane has entered the traffic pattern, he is turned over to Approach Control who responds to the plane's request for clearance to land. After the landing has been made the plane is turned over to Ground Control, who gives him taxiing instructions.

When the plane is ready to leave the process is repeated somewhat in reverse. The pilot requests clearance to taxi to the runway in use, and this permission is given by Ground Control. Clearance must be ob-

tained to cross a runway and any special instructions relative to use of taxi strips, obstructions, maintenance operations, etc. must be given the pilot. When the pilot is next to move into take-off position, he must be cleared for take-off (while the tower observes incoming traffic, etc.). After becoming airborne, the pilot must keep his receiver on the tower frequency until he has passed out of the Control Zone in order that he can receive any warnings, instructions, etc. from the tower. His last contact with the tower, then, is a request to leave the tower frequency, which is always followed by the friendly: "Good day, sir!" in a wide variety of forms.

This simple, routine procedure is, unfortunately, not always applicable. Busy days require holding procedures with frequent contacts; bad weather creates "stacking" problems in which as many as a dozen aircraft must be controlled second-after-second as the low plane is peeled off the bottom and all must be told to move down on their separate frequencies. There is the constant problem of the aircraft unequipped with radio who must be given light signals, the plane with erratic light signals, the plane with erratic radio when clear acknowledgement is not always given, the plane ready for take-off whose pilot is not satisfied with his engine performance and those behind him must be directed around him. (It is an unwritten law that a plane relinquishing his No. 1 position must go to the end of the line.)

One problem of the traffic controller not readily appreciated by the layman is that of constant surveillance and control of ground vehicles, airport wanderers, stray dogs and even a horse or cow (although not at Washington National). A visitor's first trip to an airport usually begins with his frustration by the firm fencing and guarded gates completely encompassing it (Washington National is protected on two sides by the Potomac River—and this doesn't prevent youthful oarsmen from wandering on to the field!). This fencing is a source of great comfort to the tower people and a far cry from the remarkably recent day when throngs rushed out to meet incoming airliners! The problem of the commercial delivery truck, the private pilot's convertible, the mechanic's motorcycle wandering about the aprons and taxiways on shortcuts is a constant and thoroughly dangerous problem to the tower operator.

Thrusting all these things far in the background, however, is the concern of the Traffic Controller when the weather rolls in and the airport goes on instrument operation. The "sweating out" of instrument landings, planes in the stack and missed approaches are dramatic stories told all too well and often to bear repeating here. But it may be of interest to note that the latest official CAA tabulation shows that during 1950 the skill and alertness of CAA radio communicators in reply to 475 emergency calls averted what might have been 1,560 fatalities and loss of aircraft valued at $15,500,000! Most of these calls were from pilots lost or caught in bad weather and CAA communicators habitually demonstrate that it is possible for a man sitting in a little room on the ground 40 or 50 miles away to "fly" an airplane and bring the craft out of an emergency situation to a safe landing. A large number of the communicators in the 459 CAA stations are pilots themselves and all are thoroughly familiar with the appearance of the ground from the air in the areas covered by their station (explaining why communicators are seldom transferred between stations). There is always a slight chill that runs up the spine of a CAA communicator when his receiver picks up a garbled message that says: "I am lost!" In one instance the powerful searchlight of a drive-in movie theater was used to orientate a lost pilot. In another, a well-known local swimming pool was the clue to the pilot's location. On one occasion a CAA communicator working entirely by radio directed a lost pilot out of a spin three separate times, advised him of his location from his descriptions of the ground through broken clouds, told him how to set his altimeter and finally manoeuvred a scheduled airliner nearby into position in front of the lost pilot and brought him to a safe landing, the entire performance requiring 2 hr. 22 min.

Traffic control communications recording machines. These make Dictaphone records of all conversations and messages taking place between tower and aircraft.

of constant work, while all traffic at the airport, including planes in the air, was completely suspended!

Probably these heavy responsibilities reached their zenith on December 29th, 1948, when an airplane bearing the President of the United States was brought in to National Airport by GCA in zero-zero weather, certainly the most valuable cargo ever "saved" by an unsung air traffic controller. Often these young men save lives in action far removed from the direction of aircraft in flight. Typical is the recent action of Lawrence H. Sturkey and Norman B. Horton, Airport Traffic Controllers at Charlotte, North Carolina. An aircraft crashed on take-off and both these courageous

U.S. Secretary of Commerce Sawyer (right) awards the Department of Commerce Gold Medal to Airport Traffic Controllers Horton (centre) and Sturkey (left) for their devotion to duty.

men rushed to the plane, already enveloped in flames. Mr. Sturkey disregarded his own safety and rushed into the plane twice to rescue passengers. Mr. Horton raced to a fire extinguisher and brought it to the plane to delay the spread of the flames until an emergency crew arrived. For this heroic action, both were presented the Gold Medal of the Department of Commerce by Secretary Sawyer.

Unquestionably hundreds of other Airport Traffic Controllers deserve medals for countless less-dramatic actions in their day-to-day routine of bringing airplanes in to a safe landing. But they would much rather have the surprisingly frequent handclasp they receive from burly, inarticulate airline captains who, after crossing the Atlantic and sweating out an hour in the stack and a missed instrument approach or two are finally taxied to their discharge gate with 40 passengers delivered safely. Those mumbled: "Thanks, Bud!" messages are the heartfelt rewards of an all-too-often thankless job.

An Airline Operator's Point of View on Airport Operation

BY DR. A. PLESMAN,

PRESIDENT, KLM ROYAL DUTCH AIRLINES

Functions of an airport

The demand for air transport will grow in the future. At present, however, aviation authorities, administrations and politicians are imposing artificial restrictions on the free development of air transport.

The airport is superior to the seaport, as the former is normally accessible from all directions of the compass and can be reached from any part of the world without trans-shipment, whereas the approaches to the average seaport do not usually range through more than 180° for sea-going vessels.

Nevertheless, the airport restricts to a certain extent the capacity of the air route, which is in itself of unlimited capacity.

The airport is the point of contact for surface transport and air transport and the latter will play a major role in promoting international trade and world unity.

Maximum safety at the airport is essential. ICAO has laid down conditions which the different classes of airports must fulfil. Aircraft should be able to land and to take off throughout the 24 hours. As night flying becomes the general rule, runway lighting systems must incorporate the newest devices; in addition, the use of radar and radio aids is normal routine to ensure better landing conditions at those airports where bad visibility often occurs.

It must be possible to handle aircraft quickly and economically at the airports. The passenger accommodation and the passport and Customs formalities should therefore be simplified and organized in such a way as to cause passengers the minimum inconvenience and loss of time.

The development of air transport is handicapped by high costs resulting from many factors, such as operating expenses, fuel prices, currency regulations, etc. These costs must be reduced in future. The lower the fares and rates for passengers and freight, the greater the volume of traffic; this means that more aircraft will be used, and the airport will then be required to handle more aircraft movements. If reductions in fares become feasible at a time when cruising speeds are rising, two favourable factors will combine to increase the volume of air traffic. The airport management has to keep an eye on this development and support it wherever possible, with a view to securing the fullest benefit for the airport. At the moment, many airports are by no means fully utilized, with the result that a large proportion of the capital investment is unremunerative.

The main function of the airport is to provide cheap and quick handling for aircraft, and to facilitate as much as possible the movement of passengers and goods. This is not yet generally understood.

Airport managements all over the world must therefore be persuaded that in the long run it will be to their own advantage to furnish such service. Airports can only be operated on a remunerative basis if they are utilized to the maximum extent, and if the design is based on traffic requirements as well as economic considerations.

Airport planning

It is common knowledge that the airport must be constructed in a way enabling aircraft to take off when carrying their maximum payload (*i.e.* the airport must be safe for aircraft to take off even if one engine fails).

The surrounding country should therefore be as flat as possible and the runways long enough to ensure maximum economic utilization of the airport.

The introduction of the tricycle landing-gear has made it possible to reduce the number of runways. This is a great saving, as runways are the most expensive items in airport construction.

At some places the meteorological conditions are such that one runway will suffice. Through the use of the tricycle landing-gear, the maximum number of runways now required is three while at many airports two runways may be sufficient.

In addition to runways, taxi strips and aprons are essential. The airport designer must plan the lay-out so that the maximum facilities will always be available both now and in the future. The buildings at the airport depend on the amount of traffic, and in many cases they are far below standard. As the airport is a point where travellers from abroad make their first acquaintance with a country, it is essential to have fine terminal buildings which create a good impression.

It is obvious that facilities must be provided for car parking, car servicing and organized excursions. Many airports have workshop space available so that technical assistance can be furnished. At large airports the fuel supply service is highly developed. If we take the airport as a whole, it may be regarded as a self-contained community in course of development.

It is desirable to provide good housing for officials, airline personnel, ground crews, etc., in the vicinity of the airport.

There is a great difference between the airport of the early days of aviation, the airport of the present day and the airport of tomorrow. During the 1920-1926 period, an ordinary grass field was adequate. Between 1927 and 1933 a concrete apron was provided, and in the 1933-1940 period an apron and runways became available. During the period from 1941 to 1947 complete runway systems with taxi strips and aprons were built (these runways were of limited strength). More runways are now being constructed (1948-1954). Runway systems will be perfected and the terminal buildings improved, and development will continue in succeeding years until the airport ultimately becomes an independent self-supporting organization.

Capital and Operation

The capital expenditure involved in the construction of an airport is very considerable and may vary between $10,000,000 and $150,000,000. Needless to say, such an investment can only be risked if a thorough study is made of the lay-out of the airport. It is important to choose a site where further expansion will be possible. A master plan is essential for this.

In some countries the capital required for the construction of an airport is supplied by the Government, while in other countries it is furnished jointly by the Government and the town in whose vicinity the airport is situated. In very exceptional cases the capital is furnished by private interests. As the operating results of most airports show a deficit, it is practically impossible to obtain private capital for airport construction. But the very fact that an airport is an unremunerative enterprise makes it essential to find the best possible system of operation, *i.e.*, a system which will give the airport a chance of breaking even and at the same time allow it to accomp-

lish its fundamental purpose (viz., to give optimum service to the community) through high utilization. The cost of construction is sometimes borne by authorities other than those who are responsible for the operation and management of the airport. This separation of responsibility can hardly be to the benefit of the airport management.

The enormous expenditure involved in the construction of an airport is supposed to be incurred for the future benefit of civil aviation. This makes it necessary to have a clear idea of the traffic prospects of the airport. But it is exceedingly difficult to form a picture of the future traffic potential because one must reckon with the technical development of aircraft, which enables the airline operator to reduce rates and fares and thus increases the volume of air traffic.

The airport specialist must therefore begin by making a study of the ultimate volume of traffic to be handled by the airport. This subject has been thoroughly studied by some airport authorities, and an analysis of their findings will be very illuminating for the airport manager. However, many airports seem to have been constructed without any such study, with the result that the buildings are too big for present-day traffic and will not be fully utilized for many years to come.

To encourage the development of civil aviation, it is of the utmost importance that the landing and housing charges should be as low as possible so that the airline operator can cut down his variable costs. It is also important that the system of landing fees should be standardized on a world-wide basis.

Many experiments have been made in the construction of airports, and some of these have been failures, but it is economically unjustifiable to make the airline pay for such failures. Should this mean that the operating results will always be in red, however, it is advisable to write off part of the capital investment so that a reduced amount of capital appears on the balance sheet and the enterprise can be made remunerative.

Management

In our opinion the best form of organization to operate an airport is a limited company. Even if the Government owns all the shares of such a company, it is advisable that a board of directors should be appointed to supervise the general operation and give guidance and support to the airport manager.

In cases where the capital has been provided by the Government and the municipality concerned, the shares must be held by both of these bodies, but in that case, too, it is essential that the board should include a few businessmen or bankers, whose background of commercial knowledge and experience will be of great value.

At large airports the manager should have two assistant managers, one for the technical side and another for the commercial side. The latter should be able to secure the maximum amount of revenue from the general public—as opposed to the airlines—by making the airport attractive.

The airport now occupies a prominent place in the social life of the community. In many countries enormous numbers of sightseers pay for admission in order to visit the airport and use the restaurant and other facilities which are specially provided to attract as many visitors as possible. Some airport managers are able to obtain enough revenue from this source to cover part of the operating expenses. The advantages of this are twofold, for besides covering expenses it helps to make the public air-minded and to develop civil aviation in general.

Supposing that there are sixty large airports concerned with world air traffic, it would be very desirable if these sixty airports could be operated more or less on the same lines and with a uniform system of landing charges and other regulations.

It is anticipated that there will be an enormous increase in civil aviation between 1950 and 1970. This development must not be hampered by lack of airports or by poor management.

Despite the fact that international air transport services are operated by different airlines, these services should be regarded as a single world-wide organization in which good management of airports can play a very important part, to the advantage of the public, the postal authorities and business in general.

Airport operators must definitely do something themselves to promote civil aviation, so that they too may have the satisfaction of seeing international air transport grow continuously. But they are hampered in their activities, because national air policy is laid down by a central body which is usually restrictive in its outlook, with the result that the airport operators have to wait until traffic is allowed to come to them. This means that the central body is more or less responsible for the losses incurred by airports. It is to be hoped that the time may come when airport operators will be free to run their own business, merely being co-ordinated by the central body.

Airport Economics Still Far From Ideal

BY IR. G. C. VAN WAGENINGEN, NETHERLANDS AIRPORT CONSULTING OFFICE

The ideal airport

Anyone engaged in a detailed study of the problems faced by the airport operator will find it increasingly difficult to describe the "*ideal airport*." It is easier to mention a number of attributes which the ideal airport should possess, but as a rule it will be found that these qualities alone do not make the airport ideal. This is because many of the more desirable features are all too often incompatible. For example, the ideal site for an airport is one that affords maximum safety for arrivals and departures. An area of flat ground free from obstacles is most suitable in this respect. The ideal airport, however, should also be situated in the immediate vicinity of a large city, but... wide expanses of level ground without any obstacles are seldom to be found near important population centres.

Some people regard it as ideal if an airport has sufficient runways to ensure that aircraft can take off (or land) into the wind, no matter what the direction or velocity of the wind may be. But it is difficult, if not impossible, for such a runway system to satisfy the ideal which the airport operator has in mind, viz., that instead of being a financial burden his airport should be an economic asset (if the latter can be proved by figures, so much the better).

Several other ideal features might be mentioned, *e.g.*, position in connection with town extension schemes, proximity of other large cities or industrial centres, climatological factors, etc.

Those familiar with the problems involved in airport operation and airport design will appreciate that the ideal airport—if such a thing exists—is nothing but an exception. Usually the airport will be a compromise rather than an ideal solution.

Approach to airport problems

There is a striking difference in the manner of approach to airport problems (in the widest sense) in the United States as compared with other countries.

In the United States, both the Civil Aeronautics Administration and the Air Transport Association of America pursue an active policy in regard to airports. The C.A.A. studies the special problems of particular airports, and in addition both the C.A.A. and A.T.A. study numerous questions affecting many if not all airports. This permits the compilation of data concerning a large number of airports, both large and small. The published findings of these organizations are often discussed at conferences, thus becoming more common property.

When a state or a city in America wishes to build a new airport or to effect large-scale improvements to an existing airport, the usual practice is to engage an airport consultant, who may be supposed to have conscientiously kept himself informed of developments in this field. As a general rule this means that the airport consultant must have made a thorough study of the characteristic aeronautical aspect of airports as well as the civil engineering aspect. A project is then drawn up by the airport consultant in close collaboration with the local authorities, and finally it is submitted to the C.A.A. for approval in connection with the allocation of a federal grant.

Elsewhere, however, the position is different. For purposes of comparison, special reference may be made to Western Europe, because Western Europe lends itself admirably to comparison with the United States, as both territories have a population of the same size.

None of the national territories in Western Europe, however, are large enough to make it economically justifiable to construct and operate more than one or two—or in some cases three—large airports. The result is that each of those countries lacks the all-round experience and also the specialised knowledge which is amassed in the United States by the C.A.A., A.T.A. and the consulting engineers. Also, in Western Europe there has not been much co-ordination in this field.

Airport projects are usually handled internally in the Western European countries. Knowledge of other countries' plans is mainly due to visits exchanged by officials who are in charge of a particular project, and who come to see and hear how their colleagues solved problems similar to those with which they themselves are confronted.

There is little or no regular contact of a more frequent nature, reports are seldom exchanged, and meetings or conferences on airport matters are almost unheard of. In the United States, on the other hand, operators of large airports meet twice a year to exchange experiences and reports, *e.g.* within the framework of the Airport Operators Committee and other organizations.

The question arises whether as a result of this different approach to airport problems the traveller or the airman notices a marked difference between airports in the United States and airports elsewhere. As far as the traveller is concerned, there is little or no difference, while the only thing the airman may notice is that in the United States there are probably more airports equipped with high intensity runway lighting, certain systems of approach lights and a greater variety of instrument landing aids. In general, however, it may be said there is still a lot to be desired and plenty of room for improvement everywhere, in the United States as elsewhere. Furthermore, there are many airports outside the United States which are by no means inferior to the American ones.

Nevertheless, there remains the fact that intensive exchange of views on this subject takes place only in the United States. The discussions in America spring from an endeavour to put airport operation on a reasonably sound economic basis.

Airport Economics Seen by ICAO

In 1948, ICAO issued a circular entitled "Airport Economics (Preliminary Study)." This study makes no secret of the complicated nature of the problem, and in it ICAO was obliged to utilize mainly American and Canadian data for the simple reason that there was very little information available from other sources.

The first conclusion reached was as follows:

Most, if not all, international airports are being operated at a substantial loss at the present time. If air transport continues to expand in the future as it has in the past, a number of major airports may become self-supporting within a period of from five to ten years, but others are likely to remain on a deficit basis indefinitely. The development of concession revenues and increases in airport charges might produce greater revenues at certain airports but have definite limitations and can probably not solve the basic problem.

This conclusion seems to indicate the necessity of examining airport operations.

Airport Operation in General

Apart from the fact that an airport requires large capital expenditures, it is expensive to operate and considerable government subsidies are needed to cover the annual losses.

Even if one considers that these annual charges are justified by the general economic advantages derived from the presence and importance of the airport, obviously it must be essential to reduce the annual operating deficit as much as possible, especially in countries whose economic position is not particularly strong.

The operating accounts can best be reviewed by making a distinction between three different zones of the airport. ICAO, for example, follows this system in the above-mentioned study, and in the United States it is also adopted frequently. The three zones are:

a) the landing area, which includes grounds, runways, taxiways, aprons, lighting, air traffic control;

b) the terminal buildings, with accommodation for the handling of passengers, freight, and mail, office space for airline and airport personnel, etc., the control tower, restaurants, snack bars, shops, hotels—in short, all sorts of facilities for the benefit of the public;

c) the technical area, in which the hangars, workshops, warehouse, engine test bed, aprons, etc., are located; these buildings are leased to the airlines for major and minor overhauls as well as for miscellaneous repair work.

As regards the operation of these three zones, it is generally true that the terminal building area, *i.e.*, the section where the passengers and visitors are concentrated, offers reasonable prospects of showing a profit—provided that it is well designed and efficiently managed. Subject to the same proviso, it will normally be possible to avoid losses on the technical area. The landing area, however, will practically always show a serious deficit, and in many cases the deficit will be so large that the airport as a whole has to record heavy operating losses. It is safe to assume that the annual operating expenses of many landing areas amount to between 5% and 7% of the capital investment, whereas the revenue does not usually exceed 1%.

This is the "basic problem" referred to in the conclusion of the ICAO study mentioned above.

Reason for Deficits on Landing Areas

Like the operation of the airport as a whole, the operation of the landing area depends on many diverse factors. The importance of these factors varies in different countries and circumstances, with the result that it is impossible to quote figures which are universally applicable.

It may be said, however, that the lion's share of the capital expenditure on landing areas is represented by the system of run-

ways, taxiways and aprons. In operating these, maintenance charges, running expenses, interest and depreciation are by far the main items of the annual costs of the landing area.

The scales of landing charges, from which the major part of the working profit is derived, vary considerably from place to place, and consequently they do not furnish anything to go by in reviewing the operation of landing areas. Quite apart from the level of the landing charges, however, the volume and nature of the traffic will greatly affect the operating results.

Although this does not exhaust the operation problem, there is no doubt that the relationship between the dimensions and operating expenses of the runway system on the one hand and the volume and nature of the traffic on the other, is a key factor in judging the operating prospects of the landing area.

In our opinion, the landing area deficit often is partly attributable to the fact that the runway systems are too large. This is due to two main factors, viz., excessive concern for the serviceability of the airport and over-optimistic estimates of the development of air traffic shortly after the end of World War II.

The concern for the serviceability of the airport—*i.e.* ability to receive as many aircraft as possible, irrespective of the wind direction—frequently led to insufficient allowance being made for the possibilities of modern aircraft. Through the introduction of the tricycle undercarriage and higher landing speeds, an airport no longer needs as many runways as were considered necessary a few years ago. The ICAO recommendation on this subject reads as follows:

> "Orientation (Recommended Practice): At all land aerodromes a sufficient number of runways should be provided and so orientated that landing and take-off operations may be made, with a surface cross wind velocity component not exceeding 13 knots, for as large a percentage of time as practicable. This percentage should be at least 95."

In many projects, however, this recommendation has not been properly interpreted. Anxiety over serviceability has frequently resulted in attempts being made to exceed the figure of 95% by a large margin, overlooking "for as large a percentage of time as practicable."

On studying the windrose data in conjunction with the cross-wind velocity components permissible for most aircraft, it may frequently be found that even with fewer runways the airport can easily comply with the ICAO recommendation. And what is more, the degree of serviceability secured with those fewer runways will still be almost 100% (sometimes only a fraction of one percent less). A high price is therefore paid for those final percentages of serviceability, when one considers that, under certain circumstances, one runway less means a reduction of 30 to 40 percent in the capital expenditure, as well as in the operating expenses.

Prior to World War II, there may have been a tendency to design airports which were rather small for the rapidly developing air traffic; since the end of the War, however, the trend appears to be somewhat in the opposite direction. The subject of traffic estimates is far too extensive to be dealt with in the limited scope of the present article. The author discussed this particular subject in a lecture given to the Royal Netherlands Institute of Engineers at The Hague on December 14, 1950. We shall now endeavour, however, to determine the economic relationship between the type of airport and the nature of the traffic, under certain hypothetical traffic density conditions.

Relation Between Traffic and Type of Airport

Depending on the volume of traffic the apron must be able to accommodate a certain number of aircraft. On the basis of a capacity of about 150,000 aircraft movements per annum (La Guardia as a maximum), the table below shows the number of gate positions required for four presumed volumes of traffic.

TABLE I

Necessary gate positions

aircraft movements per annum	*gate positions*
150,000	25
100,000	18
50,000	12
25,000	8

It is assumed that an aircraft may occupy a gate position for half an hour for each movement.

The space required by aircraft which have to be parked for longer periods is not taken into account. Such aircraft will have to be directed to special parking places and parking fees will then be payable.

The A.G.A. Division of ICAO has classified airports according to their dimensions, the different classes being designated by the letters A to G. The terms "Class A airport," "Class E airport," etc., have gradually become common parlance.

We shall next compare the paved areas of Class A, B and C airports with two single non-parallel runways and aprons able to accommodate 25, 18, 12 and 8 planes respectively. If the total pavement area required by a Class A airport with an apron containing 25 gate positions is taken as 100%, the relative percentages for the paved areas are roughly as shown in Table II.

TABLE II

Percentage relationship of sizes of paved areas

	A	B	C
25 gate positions	100%	81%	63%
18 » »	95%	76%	57%
12 » »	90%	71%	53%
8 » »	87%	68%	50%

Besides classifying the airports according to their dimensions, ICAO has graded the strength of runways, taxiways and aprons by figures ranging from 1 to 7. In this case the pavement of the different classes must be capable of withstanding the maximum accepted frequency of traffic of aircraft imposing single isolated wheel loads of the weight shown below:

1	45,000 kilos
2	35,000 kilos
3	27,000 kilos
	etc.

It stands to reason that a Class A airport will usually have Class 1 runways, while a Class B airport will have Class 2 runways, etc., although this is certainly not a hard and fast rule.

The cost of constructing the different types of airport will in the first instance be proportionate to the size of the paved area. Secondly—subject to some reservations—it may be assumed that the costs of the above three strength classes will be in ratio of 1 : 0.9 : 0.8.

Bearing this in mind, Table II can now be converted into Table III which shows the relative costs of construction.

TABLE III

Relative costs of construction of airports with different runway strengths and dimensions

	A_1	B_2	C_3
25 gate positions	100%	73%	50%
18 » »	95%	68%	46%
12 » »	90%	64%	42%
8 » »	87%	61%	40%

Operation of landing areas

It may be assumed that the operating expenses will bear practically the same relationship to each other as the cost of construction because interest and depreciation constitute the major part of the operating expenses.

This means that if the volume of traffic is the same, the operating expenses of the A_1, B_2 and C_3 airports will be approximately in ratio of 1 : 0.75 : 0.50.

It may also be noticed from tables I and III that a 500% increase in traffic only entails a rise of between 15 and 25 percent in the operating expenses. The natural expectation that the remunerativeness of the landing area will depend on the dimensions of the system of runways, etc., and the volume of the traffic is thus substantiated.

Type of Airport and Economics

As may be seen from the foregoing, the operating results will be materially affected by the choice of the type of airport. As the choice of the type of airport largely depends on the weight of the expected aircraft we will now consider the aircraft weights in connection with the runway strengths.

The maximum admissible wheel load for Class 3 runways is 27 tons. An aircraft with single wheels can therefore use a runway of this class provided that its weight does not exceed $2 \times 27 + 10\%$, *i.e.* about 60 tons. Depending on the thickness of the pavement (which, in turn, depends on the nature of the ground), the permissible weight for an aircraft with double wheels may be taken as roughly $1\frac{1}{4} \times 60 = 75$ tons, while in the case of a machine with double tandem wheels the permissible weight will be about $1\frac{1}{2} \times 60 = 90$ tons.

Similarly, the maximum permissible take-off weights for Class 2 runways will be approximately as follows:

Single wheels	$2 \times 35 + 10\% =$	77 tons
Double wheels	$1\frac{1}{4} \times 77 =$	96 tons
Double tandem wheels	$1\frac{1}{2} \times 77 =$	115 tons

The corresponding figures for Class 1 runways will then be:

Single wheels	$2 \times 45 + 10\% =$	100 tons
Double wheels	$1\frac{1}{4} \times 100 =$	125 tons
Double tandem wheels	$1\frac{1}{2} \times 100 =$	150 tons

In general it is safe to suppose that the landing gear of the heaviest aircraft using a Class C_3 airport will not have more than two wheels on each leg. The maximum weight for the C_3 airport is therefore 75 tons.

It may be expected that the heaviest aircraft using class A_1 airports will be equipped with four wheels on each leg of the landing gear. The maximum weight for this class can therefore be taken as 150 tons.

The Class C_3 airport is amply sufficient for all four-engined commercial aircraft now in use, while airports of an even lower classification will suffice for some of these aircraft.

Recapitulating, as far as can be judged at present the choice of an A_1 airport for commercial aviation is only justifiable on economic grounds in a few exceptional cases.

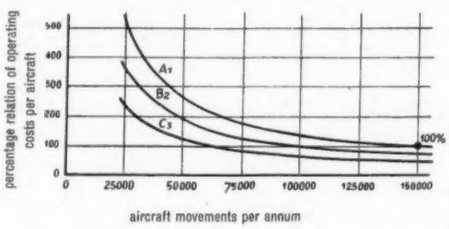
It is no more necessary for the majority of airports to have an A_1 runway simply because the Brabazon exists, than it is for every important seaport to be dredged to provide such a depth of water as would be required for the few existing giant liners.

The operating costs of the landing area will have to be covered by the landing fees, which in turn depend on the nature and the volume of the traffic.

Landing fees differ considerably. There are various reasons for this, but in the present article it must suffice to state that landing fees are usually proportionate to the weight of the aircraft.

It is therefore important for the airport operator to know the average weight as well as the number of aircraft using his airport.

Taking this into consideration it is possible to determine the ratio in which the operating costs will decrease as the traffic increases. This is shown in the graph below. As in the previous tables, the operating costs of the A_2 airport with 25 gate positions (150,000 aircraft movements per annum) is supposed to be 100%.



With the aid of this graph it is possible to determine the volume of traffic and the average weight of the aircraft which—on the basis of the local revenue from landing fees and the operating costs—would permit the airport to break even. This may be referred to as the "critical load factor" of the airport. Should the traffic still be considerably below the critical load factor, the question arises as to whether the landing charges are too low or the operating costs too high.

In this connection it must be remarked that if the volume of traffic is the same and if the weight-scale type of landing tariff is applied, the average weight of the aircraft using an A_1 airport must be twice as heavy as the weight of those using a C_3 airport, in order to secure similar operating results with identical tariffs per ton weight.

If the required average weight cannot be attained, the operating results of the A_1 airport will remain very unsatisfactory even when the volume of traffic is such that on a C_3 airport the critical load factor would be within reach.

It is even conceivable that the critical load factor may still be unattainable if traffic increases up to the maximum capacity of the runway system unless... the level of the landing fees is raised considerably. This, however, would be an unjustified charge on the airlines.

Conversely, given a large volume of traffic, if the airport is designed on sound economic lines it ought to be possible to levy landing charges which will balance the operating expenses.

The configuration of the graph shows that unfavourable ratios between the operating expenses and the revenue from landing fees are almost inevitable when the traffic volumes are comparatively small.

The degree to which these ratios may be improved, however, then falls beyond the scope of airport management and becomes a question of air policy.

Recapitulation

In the present study we have devoted special attention to the economic aspect of the landing area, but there are other factors which also influence the design of an airport. Sometimes, for instance, it may be necessary to have extra runways in order to maintain capacity under instrument landing conditions. Also, when the volume of traffic is exceptionally large, the operating costs will increase slightly beyond what is assumed in our example—but allowance can be made for this in actual practice.

In the above study of the airport zone which is usually weakest from an economic viewpoint, viz. the landing area, the use of hypothetical traffic volumes has enabled us to throw light on the importance of good estimate of the weights of future types of aircraft. It was found that the average weight of the anticipated traffic will greatly affect the operating results of the different classes of airport.

Numerous airport projects incorporate too many runways, and excessive allowance is made for mammoth aircraft which may only be suitable for very special routes.

For these two reasons, many an airport will suffer operating losses irrespective of the volume of traffic, and will continue to do so until the average weight of the aircraft constituting that traffic is much higher than at present. In many cases, the average weight will have to be doubled. For the time being, the feasibility of such an increase must remain an open question.

The volume of the traffic and the average weight of the aircraft proved to be determining factors in arriving at the critical load factor of the airport. That load factor depends on the volume and the average weight of the traffic, on the one hand, and the operating costs on the other.

We trust that this study may have made it plain that the weak economic position of the airport is largely attributable to the runway systems, which are too large for the traffic actually using them.

The traffic at many airports is still of such a nature that national air policy plays an important part in fixing the level of landing fees. This is a clear indication that the economic position of the airport is indeed far from ideal.

New York International Airport, Idlewild. This huge facility is still under construction. Terminal buildings (along the dark apron in the centre) are still only temporary.

World's Largest Airport System

The Four Airports of New York

BY HOWARD LEVY AND WARREN D. SHIPP, NEW YORK

THE NEW YORK PORT AUTHORITY

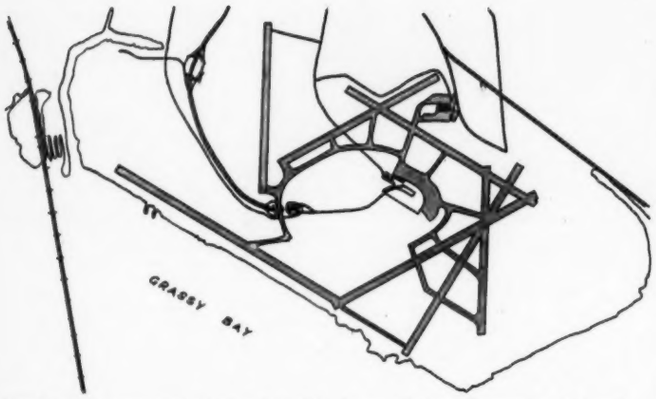
The metropolitan region of New York and New Jersey has developed around the greatest harbor in the world. A port of many ports, it extends along 650 miles of water front. Numerous cities border the shores, and a state boundary line runs down the center of the Hudson River and of the harbor.

The trade and commerce that nourish the harbor area, in which reside some 9 per cent of the population of the United States, had brought with it problems of congestion, duplication of effort, and wasteful competition. It was to solve these problems, all regional in character, that The Port of New York Authority was created in 1921. The founders of The Port of New York Authority recognized that the New York—New Jersey Port is a geographic and economic unit. They understood that its transportation problems—land, sea, and air—required a regional approach and a regional solution by a regional port development agency.

The Port Compact creates the Port Authority and provides that it "*shall constitute a body with full power and authority to purchase, construct, lease and operate any terminal or transportation facilities*" within the Port District. The Port District is an area which includes, roughly, that part of the metropolitan area in New York and New Jersey lying within a radius of twenty-five miles of the Statue of Liberty. The Port Authority is a self-supporting, nonpolitical agency of the states of New York and New Jersey, having the distinguishing mark of relying upon the revenues from its projects rather than from funds that come directly or indirectly from taxation.

Over the past thirty years the Port Authority has sold over $675,000,000 of revenue bonds on its own credit, backed solely by the revenues and reserves of its own projects. It has built or has under construction more than $50,000,000 worth of bridges, tunnels, waterfront facilities, airports, and consolidated truck, bus and railroad terminals. Its regional system of air terminals include *New York International Airport (Idlewild), LaGuardia, Newark, and Teterboro*, all located within the Port District.

Hervey F. Law, General Superintendent of Airports, Port of New York Authority; America's most famous airport manager.



New York International Airport, Idlewild, the world's largest commercial airport.

Apron loading area at Idlewild; temporary control tower at right.

Austin J. Tobin, Executive Director of The Port of New York Authority recently explained the reasons behind the Port's operation of these four major airports. He said, "Having constructed or planned consolidated terminals throughout the Port area for railroads, buses, trucks and ships, we were asked a few years ago, both by the cities of Newark and New York, to survey their airports and to submit a proposal for Port Authority financing and operation. We concluded that, over a long development period, the airports of New York and Northern New Jersey could be operated on a self-supporting basis. In 1947, we signed fifty-year leaseholds covering the future development and operation of LaGuardia, New York International, and Newark airports. Early in 1950, we also made provision for the airport requirements of the future by purchasing Teterboro Airport in Bergen County, New Jersey, which is only twenty minutes by bus from the Lincoln Tunnel in New York. Under Port Authority management, the air transport needs of our metropolitan area are now met by a regional system of airports, rather than by competing airports under several municipalities..."

MOST FAMOUS AIRPORT MANAGER

The man directly responsible for the world's largest integrated airport system has also become the most famous airport manager of the United States and, indeed, of the world. *Hervey F. Law*, The Port of New York Authority's General Superintendent of Airports, is in complete charge of the four facilities, and despite his huge responsibility he maintains the air of a man whose work is his top pleasure. He has the flyer's ruddy complexion, a ready tongue, a quick smile and lots of high-octane enthusiasm for tough problems. He hardly looks his 51 years, and is today as energetic and enthusiastic as he was back in 1914 when he soloed in his home-made glider.

Before joining the Port Authority on July 1, 1947, Hervey Law was the Authority's Consultant on Airport Operation during its survey of the New York airports. He was credited with making Washington National Airport, which he managed, the best run in the country.

The professional career of Hervey Law in air transportation began more than thirty years ago when he was a civilian instructor for the aviation section, United States Army Signal Corps. He has lectured on airport problems at New York University, Brooklyn Polytechnic Institute, and American University in Washington, and is co-author of "Airport Design, Construction and Management," published in 1946 by McGraw-Hill. One of his treasured possessions is the flying licence issued to him in 1917 by the Fédération Aéronautique Internationale, nine years before our own Federal Government began to standardize the requirements for pilots.

A member of the Airport Advisory Committee of the CAA, Mr. Law is also a director of the Airport Operators Council, and is a former Vice-President of the American Association of Airport Executives.

LAGUARDIA AIRPORT—DOMESTIC AIR TERMINAL

The first of the four airports to come under the jurisdiction of The Port Authority is LaGuardia Airport, one of the busiest air terminals in the world. Originally New York's only large air terminal, it had a Domestic Air Terminal and an Overseas Air Terminal. Following inauguration of New York International Airport at Idlewild, most international operators moved to the new facility, so that LaGuardia today is chiefly the terminal of the domestic services to the metropolis. Covering 550 acres, it is located in the north-western section of Queens County, New York City, bordering on Flushing Bay and Bowery Bay, and is only eight miles by highway from Grand Central Station at 42nd Street in New York. It was opened to commercial flying on December 2nd, 1939, and the Port Authority lease became effective on June 1st, 1947. There are three active runways: Northwest-Southeast (13-31) 5800 ft. × 200 ft.; Northeast-Southwest (4-22) 5000 ft. × 200 ft.; and East-West (9-27) 4500 ft. × 150 ft.

The ten active hangars cover a total area of 510,000 sq.ft. and are equipped to handle every type of aircraft that uses the airport. Two other hangars are now being used for storage and will be activated when conditions warrant. Curving gently outward from both sides of the Domestic Terminal Building is a 1,500-foot long Observation Deck which accommodates about 3,500,000 visitors a year, 2,500,000 of whom are children under twelve and elementary school groups that are admitted free.

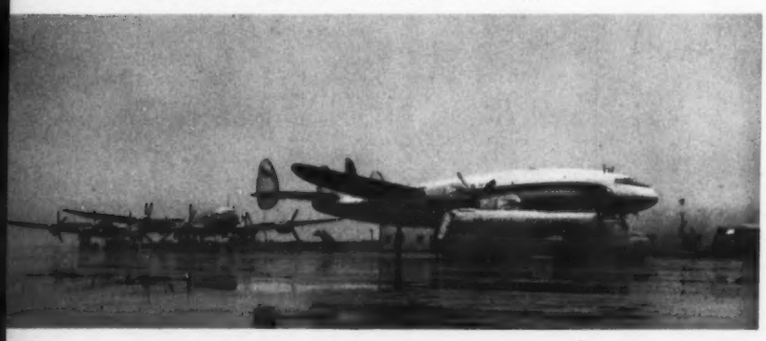
In 1950, LaGuardia handled 156,470 plane movements accommodating 3,631,275 passengers, or more people than the population of America's second largest city, Chicago. In 1949, there were 159,465 plane movements that accommodated only 3,284,214 passengers, indicating that the increased payloads of the latest airliners are helping to solve the big problem of airline congestion at this field. Total cargo traffic for 1950 was 117,255,060 pounds of which 103,280,091 pounds was domestic, and 13,960,649 pounds went overseas.

Since 1947 when the Port Authority assumed responsibility for the operation of the airport, there has been a program of accelerated concession development which to date has shown the wisdom of such development. Concession revenues at LaGuardia in 1949 totalled $526,864 as compared with $358,265 in 1947. This is despite the fact that the layout of the Terminal Building is fundamentally wrong in that only about 30 per cent of the arriving and departing passengers move through the Terminal building itself, so that 70 per cent of the passengers and their guests have no opportunity to patronize the Terminal's services and facilities. Under Port Authority management the net operating surplus in 1949 was $210,755 as compared to a net operating loss of $74,234 in 1948.

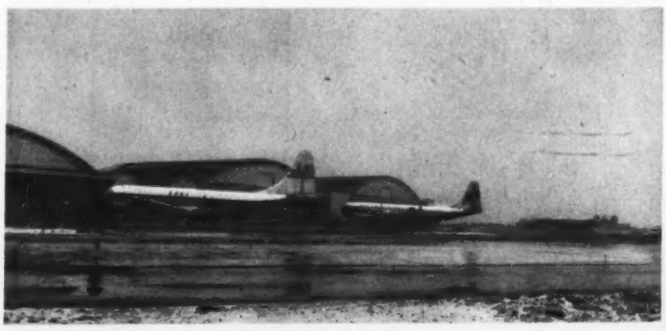
The Civil Aeronautics Administration has installed and is operating the very latest in radio equipment which has made the Control Tower at LaGuardia one of the finest in the U.S.A. Permanent Instrument Landing System (ILS) and Ground Controlled Approach (GCA) are also in operation.

The airplanes flying in and out of LaGuardia bear the familiar and colorful paint jobs of American Airlines, Capital Airlines, Colonial Airlines, Eastern Air Lines, Northeast Airlines, Northwest Airlines, Pan American Airways, Trans-Canada Air Lines, Trans-World Airlines, and United Air Lines, along with occasional military and commercial craft.

Rain or shine, the Idlewild loading ramp in front of Customs is always busy. Pictured are two "Constellations" of Air France and one of KLM.



PAA and BOAC use these three giant hangars at Idlewild. They have a total area of 282,239 sq.ft. and have just recently been completed.



A KLM Douglas DC-4 parked in front of the yet incomplete permanent Operations Building at Idlewild. The other side of the building will be the freight terminal.

A BOAC "Stratocruiser" making a landing over the slope approach lights at Idlewild by means of GCA. Photograph was taken in rain and extremely poor visibility.

IDLEWILD—NEW YORK INTERNATIONAL AIRPORT

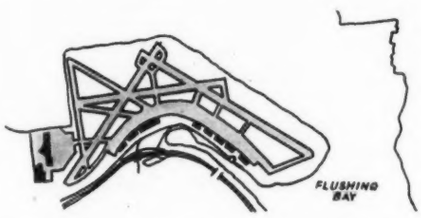
All the major international and overseas air lines to New York terminate at the Port Authority's International Airport, the largest commercial airport in the world. Formal dedication took place July 31st, 1948, on the opening day of a nine-day International Air Exposition, which was a part of the Golden Anniversary celebration of the City of New York. It is located in the south-eastern section of Queens County, New York City, bordering on Jamaica Bay, and is fifteen miles by highway from 42nd Street in New York.

Nine times larger than LaGuardia, it boasts six open parallel runways, all 200 feet wide: A = 8,000 feet long, B = 6,000 ft., C = 8,200 ft., D = 9,500 ft., E = 6,000 ft., F = 6,500 ft. A seventh, Runway V, the instrument runway, is 8,000 feet long. The reinforced concrete runways are 12 inches thick, the taxiways and aprons are 13 inches thick, sufficient to support any of the craft of the fourteen airlines now operating from its 4,900 acres.

When the Port Authority took over the operation of New York International there were two hangars each 300×185 feet. Since then the Port Authority has constructed and has in operation the three largest steel arch hangars in the world, each 300×318 feet, and each capable of housing four Boeing Stratocruisers. Other structures include a Temporary Terminal with Quonset type extensions to house passenger waiting rooms, concessions, airline ticket offices and operational offices, emergency equipment, Port Authority operations, and various Federal agencies. The Control Tower is located on the roof of the Terminal building and is equipped with the very latest radio equipment.

The first permanent building erected by the Port Authority was the $5,000,000 Federal Building. It is tenanted by the regional offices of the CAA and the CAB, and the Weather Bureau with a combined staff of over 400 people. The first installation of the slope line approach light system developed by the CAA for airport instrument runways was commissioned by the CAA, at whose request the system was installed and by whom it will be maintained. Two piers were built to carry the lights 2,000 feet over Jamaica Bay from the southerly end of runway V.

Between April, 1942, and May, 1948, 60 million dollars was expended by the City of New York on the construction of the airport. As of May 31st, 1950, the Port Authority had spent or committed about $36,500,000. Future development is in the multi-million dollar bracket.



LaGuardia Airport, New York, terminal for the U.S. domestic air services.

Control Tower at LaGuardia, operated by Civil Aeronautics Authority personnel.

In 1950 New York International Airport handled 19,275 plane movements, carrying almost 400,000 passengers. Total cargo traffic was 21,160,905 pounds of which 5,106,402 pounds were domestic and the overseas was 14,187,060 pounds. Non-scheduled and cargo lines accounted for the remaining 1,867,443 pounds.

From the 380-foot long observation deck which is to be increased by 350 feet, 450,000 visitors in 1950 watched the operations of Aerolineas Argentinas, Air France, British Overseas Airways, Israel National Airlines, KLM-Royal Dutch Airlines, Linee Aeree Italiane, Linea Aeropostal Venezolana, Loftlieder, the Icelandic National Airlines, Northwest Airlines, Pan American Airways System, SABENA—Belgian Air Lines, Scandinavian Airlines System, and Swissair.

NEWARK—A SPECIAL AIRPORT FOR NEW JERSEY

Opened in the infancy of commercial aviation, Newark Airport began its history in 1928 serving as the east coast terminal for the young airlines that were in existence in those days. Located favorably close to the dense industrial and residential areas of Northern New Jersey and on a highway leading directly to the west side of New York City, its future importance is assured to both air passengers and shippers from the entire region. Operation of Newark by the Port Authority commenced in 1948. The three 150-foot wide runways are 5,940, 7,120 and 7,300 feet long. There are eleven hangars, 7 for civilian use with a total area of 286,185 sq.ft., and 4 for military use totalling 125,684 sq.ft. Newark Airport occupies an area of 1,400 acres and under present plans will be expanded to 2,200 acres.

During 1950 Newark Airport handled 89,171 plane movements and 1,055,406 passengers. Total cargo traffic, all of which was of a domestic nature, was 109,102,867 pounds. Over 50 per cent of all the domestic cargo handled in the New York—New

City bus and taxi service direct to Airlines Terminal Building at LaGuardia.

Parking lot at LaGuardia. In foreground coaches of the Carey Transportation Corp. which carries passengers between city terminal and airport (against payment !). At right the curving observation deck, unusually empty owing to the cold windy day on which the picture was taken.

Looking out on the loading apron at LaGuardia from the Control Tower.

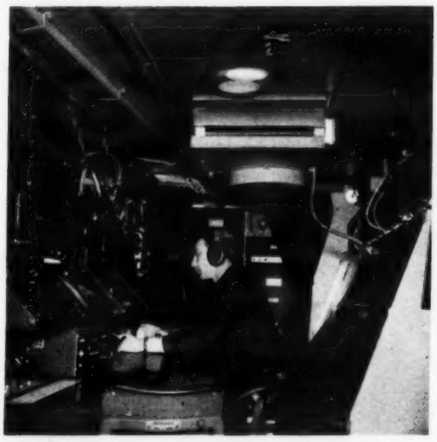
Newark Airport, third major air transport facility operated by N.Y. Port Authority. An EAL "Constellation" being prepared for take-off.

Jersey area flows through Newark Airport. Because of a heavy increase in traffic during 1949, the Port Authority devised a four-runway plan for Newark with a peakhour capacity of 120 planes. The open parallel runways, to cost $20,000,000, will be aligned in two directions at an approximate 90 degree angle to each other, and will give coverage under any wind conditions.

Expecting the volume of air traffic to triple within the next fifteen years, the Port Authority has begun construction of a new Passenger Terminal Building at Newark. Estimated to cost $6,000,000, the new building will contain five times the floor space of the present Administration Building, and is designed to accommodate an increase in air passengers from the 1949 figure of 834,916 to an estimated 2,712,000 in 1965.

In operation at present by the CAA is a mobile GCA unit, and a permanent ILS assures safe flying conditions in all kinds of weather. Among the airlines using Newark are American Airlines, Eastern Air Lines, National Airlines, Robinson Airlines, Trans-World Airlines, and United Airlines. Carrying air freight only we find Capital Airlines, Flying Tiger Line, Slick Airways, and U.S. Airlines.

Rear view of LaGuardia Control Tower. Water in distance is Flushing Bay.



Inside the Bendix GCA trailer at Newark. Nearly every instrument in the unit is duplicated as a safety measure: scopes, radios, generators, etc., in case one goes out of service.

TETERBORO—CARGO TERMINAL

In order to complete the overall service for all types of air transportation in its regional area, the Port Authority on April 2nd, 1949, purchased the 550-acre Teterboro Airport in Bergen County, New Jersey. Its 106,200 square feet of hangar space is divided up among seven hangars. There are three runways, each 100 feet wide, one 3,000 ft. long and two 4,500 feet. Accommodating the private flyer and the executive type craft, Teterboro also handles considerable freight. In January, 1951, there were 11,262 plane movements, and total cargo traffic for that month was 843,885 pounds. An aviation school and numerous sales and service companies demonstrating and servicing the latest in the smaller private craft will be found in among the cargo and passenger planes using the field.

Since much of the industrial development of the Metropolitan Region consists of light industry which will rely increasingly on air freight, use of Teterboro as an air freight center represents an asset to the area which could not be equalled by any other type of operation. It is expected that Teterboro's present type of operation will continue until the requirements of the developing regional air terminal program call for its expansion into a major facility. The CAA operates the control tower, and the latest type ILS has been installed.

It was at this field that Anthony Fokker, famed Dutch plane designer first began his operations in America, and one of the buildings still stands, used as a hangar for Safair, Inc.

FUTURE PLANNING

The Port Authority's budget for 1951 covers an anticipated expenditure of 66 million dollars, the largest single item of capital expenditure for the coming year being 7.5 million for Newark Airport.

An air traffic survey conducted by the Port Authority recently completed represents the most thorough appraisal of factors influencing air traffic ever attempted and releases some startling forecasts. According to the forecast, the Port District will account for 11 million air passengers in 1980; 599,400 tons, of air cargo; and 131,500 tons of air mail. An estimated 22 billion passenger-miles of travel on the domestic airlines will account for the Port District's handling of about one fourth of the nation's air passengers. The Port Authority is basing its future expansion of its four fields on the expected increase in all phases of air commerce.

Air route planning has become global in scope. New York, already linked with the many principal cities in the nation, now enjoys direct service with every continent and commercially important region in the world. Air routes radiate from the Port District across the North Atlantic to Europe, the Near East and India; across the Pacific to the Orient, by way of Alaska or Australia, to India, providing round-the-world service; southward to Latin-America and across the South Atlantic to Africa.

Over the thirty years of the Port Authority's existence, it has demonstrated that great public transportation projects can be financed, constructed and operated on a self-sustaining basis. Its projects do not require the taxpayers of the region to pay a cent more in taxes. It is anticipated that from 60 to 70 per cent of the gross revenues at the airports will be developed from non-flight sources. The Port Authority airports will be adequate both in size and location to meet the needs of the region's potential air traffic and will be the key to the New York-New Jersey Port District's competitive position in an era of air transportation.

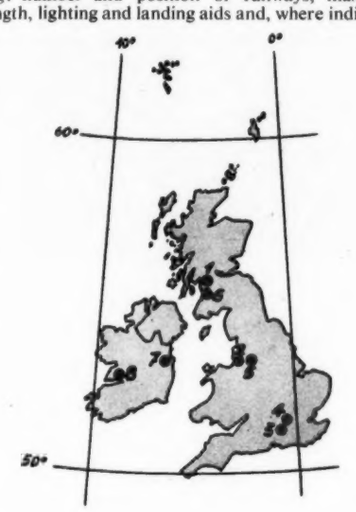
Night operations at Newark Airport, the regional airport for traffic generated on the New Jersey side of the Port Authority's area of jurisdiction. The diagonally striped object in the background is the GCA trailer unit.

Teterborough Airport, New Jersey, is the Port Authority's specialized terminal for cargo aircraft but also handles executive and personal aircraft.

The World's Major Airports

To select a reasonable list from the 2000 odd airports now in regular use is no easy matter. If the list is not to be too long it must be limited to the most important aerodromes. Since complete traffic figures are not available here, we have chosen the best-known centres of world air transport—terminal as well as transit airports—from an air timetable. Our list contains 168 airports in 22 different territories. They are divided into countries, arranged alphabetically within each group and given in the local spelling (or the English). All definitions and symbols are those used by ICAO and the most important technical characteristics of the aerodromes, *e.g.* number and position of runways, maximum ength, lighting and landing aids and, where indicated, height above sea level, given as laid down in the ICAO rules (cf. key to table). With a few exceptions all airports are designated "aerodromes of entry," that is, they have their own Police, customs and health authorities.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
Serial number (see maps)	Name of the city (or town) and of aerodrome. Height above sea level (in metres) is also shown for high altitude airports (e.g. for La Paz 4100 m).	Location in relation to town centre, distance in nautical miles and direction from centre (for Shannon position is given in relation to Limerick).	Longest runway (as a rule blind landing runway) runway number (QFU; to nearest tenth of magnetic azimuth) and length of runway (in metres). A = Approach Lights R = Runway Lights	Other Runways: Runway No. (QFU; to nearest tenth of magnetic azimuth) or number of other runways. A = Approach Lights R = Runway Lights	Radio Aids: ILS = Instrument Landing System SBA = Standard Beam Approach GCA = Ground Controlled Approach BABS = Beam Approach Beacon System RNG = Radio Range (LF, MF or VHF) VOR = Omni-directional Range (VHF) NDB = Non-directional Beacon RSP = Responder Beacon DF = Direction Finding (VHF, HF or MF)

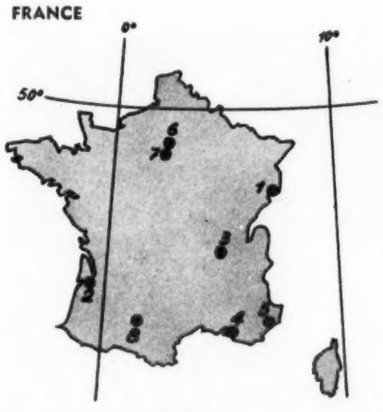


1 GREAT BRITAIN AND EIRE

The 2750 m long main runway at London Airport.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**GLASGOW**/Renfrew	5 W	08/26 1779 AR	03/21 R	SBA, NDB, DF
2	**LIVERPOOL**/Speke	5 SE	08/26 1523 AR	04/22 AR, 17/35 AR	SBA, NDB, DF
3	**LONDON**/London	12 W	10R/28L 2896 AR	10L/28R AR, 05R/23L AR, 16R/34L R	ILS, SBA, GCA, NDB, RSP, DF
4	**LONDON**/Northolt	11 WNW	08/26 1683 AR	13/31 AR	ILS, SBA, GCA, NDB, RSP, DF
5	**MANCHESTER**/Ringway	7 S	06/24 1281 AR	02/20 R, 10/28 R	GCA, SBA, NDB, DF
6	**PRESTWICK**/Prestwick	1 NE	13/31 2012 AR	08/26 AR	ILS, GCA, RNG, NDB, DF
7	**DUBLIN**/Dublin	5 N	06/24 1612 AR	12/30 AR, 17/35 AR	ILS, SBA, NDB, DF
8	**SHANNON**/Shannon	11 W Limerick	05/23 2141 AR	09/27 AR, 14/32 R, 18/36 R	ILS, GCA, RNG, DF

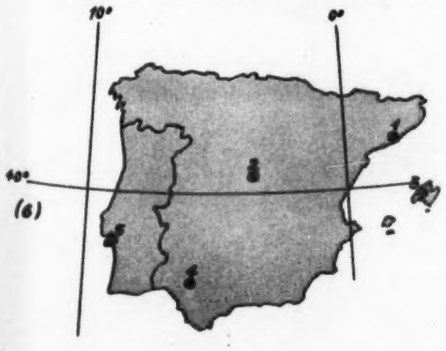
2 FRANCE



PARIS/Orly intercontinental airport: two parallel main runways, one (longer) blind landing runway.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**BALE**/Mulhouse	3 NW Bâle	16/34 1480 AR	——	NDB, DF
2	**BORDEAUX**/Mérignac	6 W	05/23 2000 AR	12/30 R	ILS, BABS, NDB, RSP, DF
3	**LYON**/Bron	4 E	17/35 1830 AR	——	ILS, RNG, NDB, RSP, DF
4	**MARSEILLES**/Marignane	14 NW	14/32 2000 AR	14/32 —	ILS, NDB, DF
5	**NICE**/Le Var	3 SW	05/23 1700 R	——	DF
6	**PARIS**/Le Bourget	6 NE	03/21 2100 R	09/27 AR	ILS, SBA, RNG, NDB, DF
7	**PARIS**/Orly	8 S	03/21 1850 AR	08R/26L AR, 08L/26R R	ILS, GCA, RNG, NDB, DF
8	**TOULOUSE**/Blagnac	3 NW	15/33 2500 —	12/30 AR	NDB, DF

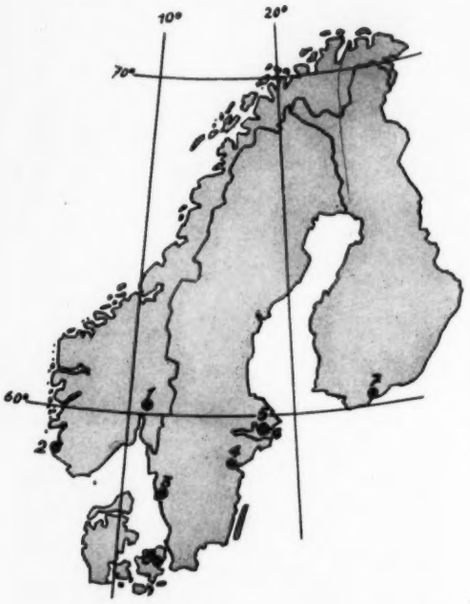
3 SPAIN AND PORTUGAL (INCLUDING THE AZORES)



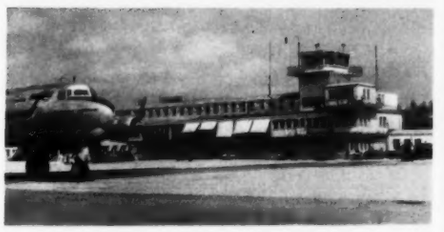
The three runways at SANTA MARIA (Açoras) are arranged in A form.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**BARCELONA**/Muntadas	7 SW	08/26 1739 R	14/32 R, 17/35 —	SBA, NDB, DF
2	**MADRID**/Barajas	6 ENE	15/33 3048 —	05/23 AR, 10/28 R	ILS, SBA, RNG, NDB, DF
3	**PALMA**/San Bonet	4 E	06/24 1555 × 1080	17/35 —	DF
4	**SEVILLA**/San Pablo	5 E	05/23 2000 —	02/20 —, 10/28 —	NDB, DF
5	**LISBOA**/Lisbôa	3 N	05/23 2080 R	09/27 —, 14/32 —, 18/36 AR	SBA, RNG, NDB, DF
6	**VILA DO PORTO**/Santa Maria Açoras	2 NW Do Porto	01/19 2440 AR	05/23 AR, 15/33 AR	ILS, RNG, NDB, DF

4 NORTHERN EUROPE



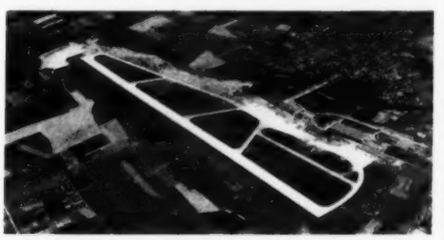
(Norway, Sweden, Finland, Denmark)



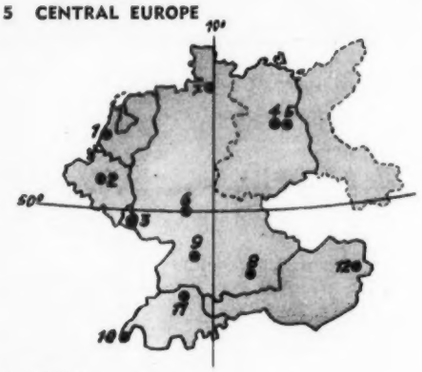
STOCKHOLM/Bromma terminal building.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**OSLO**/Gardermoen	19 NE	02/20 2000 AR	11/29 R	ILS, SBA, RNG
2	**STAVANGER**/Sola	6 SW	01/19 2550 —	04/22 AR, 11/29 AR, 14/32 AR	SBA, DF
3	**GÖTEBORG**/Torslanda	7 W	04/22 1850 AR	09/27 AR, 14/32 AR	ILS, DF
4	**NORRKÖPING**/Kungsängen	2 E	09/27 1700 AR	———	DF
5	**STOCKHOLM**/Bromma	4 WNW	13/31 2025 AR	05/23 AR, 09/27 —, 16/34 AR	ILS, SBA, RNG, DF
6	**STOCKHOLM**/Halmsjön	under construction			
7	**HELSINKI**/Malmi	6 NE	18/36 1400 —	05/23 —, 09/27 —, 14/32 —	SBA, DF
8	**COPENHAGEN**/Kastrup	4 SSE	04/22 2300 AR	09/27 R, 12/30 AR, 17/35 R	ILS, SBA, RNG, NDB, DF

GENÈVE/Cointrin : Since wind direction is relatively constant one runway suffices.



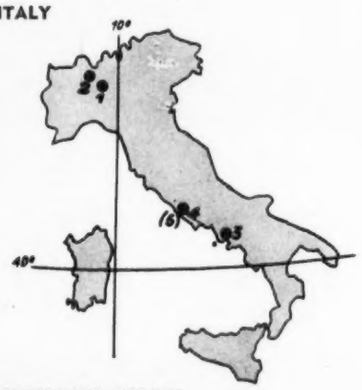
5 CENTRAL EUROPE



(Holland, Belgium, Luxembourg, Germany, Switzerland, Austria)

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**AMSTERDAM**/Schiphol	4 SW	05/23 2150 AR	01/19 R, 09/27 AR, 14/32 AR, 18/36 R	ILS, SBA, NDB, DF
2	**BRUXELLES**/Melsbroek	7 NE	07/25 2050 AR	02/20 AR, 12/30 AR	ILS, SBA, RNG, NDB, DF
3	**LUXEMBOURG**/Luxembourg	3 E	07/25 2000 —	———	———
4	**BERLIN**/Gatow	6 SW	08/26 1829 R	08/26 R	BABS, GCA, NDB, RSP, DF
5	**BERLIN**/Tempelhof	1 S	09/27 1619 A	09/27 —	GCA, RNG, NDB
6	**FRANKFURT**/Rhein-Main	6 SW	07/25 2134 AR	07/25 AR	GCA, RNG
7	**HAMBURG**/Hamburg	4 N	05/23 1879 AR	16/34 —	SBA, NDB, RSP, DF
8	**MÜNCHEN**/Riem	5 S	07/25 1907 R	———	RNG, NDB
9	**STUTTGART**/Echterdingen	5 SSE	08/26 1730 R	———	RNG, NDB
10	**GENÈVE**/Cointrin	2 NW	05/23 2000 AR	———	ILS, SBA, DF
11	**ZÜRICH**/Kloten	4 N	16/34 2600 AR	02/20 R, 10/28 AR	ILS, SBA, DF
12	**WIEN**/Schwechat	9 SE	12/30 1487 R	01/19 —, 12/30 —	SBA, BABS, NDB, RSP, DF

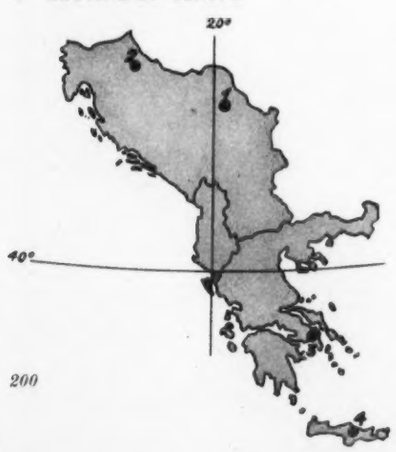
6 ITALY



Airport restaurant at ROMA/Ciampino.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**MILANO**/Linate	2 E	10/28 920 R	———	RNG, NDB, DF
2	**MILANO**/Malpensa	13 WNW	17/35 1998 AR	———	ILS, RNG, NDB, DF
3	**NAPOLI**/Capodichino	8 NE	07/25 1738 R	———	RNG, NDB, DF
4	**ROMA**/Ciampino	8 SSE	16/34 2250 R	16/34 —	ILS, RNG, NDB, DF
5	**ROMA**/Fiumincino	12 W	under construction		

7 SOUTH-EAST EUROPE

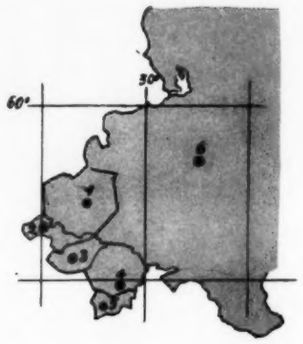


(Yugoslavia, Albania, Greece)

ATHINAI/Ellinikon, the airport for Athens.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**BEOGRAD**/Zemun	2 NW	05/23 1392 —	———	NDB, DF
2	**ZAGREB**/Lucko	6 SW	11/29 1400 —	04/22 —	DF
3	**ATHINAI**/Ellinikon	4 S	03/21 1800 R	16/34 R	RNG, DF
4	**IRAKLION**/Iráklion	3 E	12/30 1585 —	———	NDB, DF

8 EASTERN EUROPE

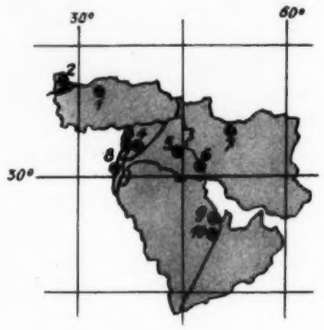


(Poland, Czechoslovakia, Hungary, Rumania, Bulgaria, Soviet Union)

PRAHA/Ruzyné is today one of the most modern aerodromes in Europe.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**WARZAWA**/Okezie	4 SSW	16/34 2000 —	02/20 —	NDB, DF
2	**PRAHA**/Ruzyné	7 W	04/22 1800 AR	08/26 R, 13/31 —, 17/35 —	ILS, SBA, RNG, NDB, DF
3	**BUDAPEST**/Budaörs	5 WSW	E/W 1372 —	———	NDB, DF
4	**BUCURESTI**/Baneasa	3 N	07/25 1189 R	———	NDB, RSP, DF
5	**SOFIJA**/Vrajdebna	4 W	10/28 1408 —	———	NDB, DF
6	**MOSKVA**/Vnukovo	...	... ...	... ...	...

9 NEAR AND MIDDLE EAST



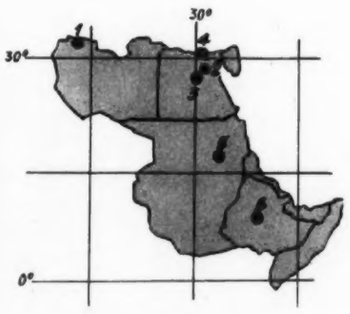
(Turkey, Cyprus, Lebanon, Syria, Iraq, Iran, Israel, Transjordan, Arabia)

TEL AVIV/Lydda : Four take-off and landing runways.

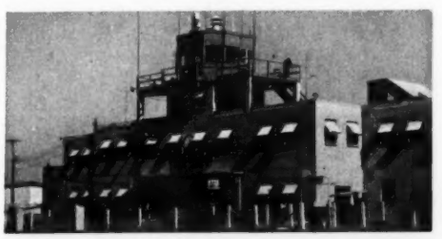
No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**ANKARA**/Civil	7 W	06/24 1450 R	09/27 —, 18/36 —	RNG, NDB, DF
2	**ISTANBUL**/Yesilkoy	12 W	04/22 1510 R	09/27 R, 18/36 —	NDB
3	**BEYROUTH**/Bir Hassan	1 S	17/35 1135 R	02/20 —, 05/23 —	NDB, DF
4	**DAMAS**/Mezze	4 SW	06/24 2400 R	12/30 R	NDB, DF
5	**BAGHDAD**/Baghdad West	2 SW	13/31 1930 AR	04/22	NDB
6	**BASRA**/Margil	5 NW	... 1830 R	three	...
7	**TEHRAN**/Mehrabad *	5 W	11/29 1829 R	18/36 —	NDB, RSP
8	**TEL AVIV**/Lydda	8 E	10/28 1920 R	01/19 R, 06/24 —, 14/32 —	NDB, DF
9	**MANAMA**/Muharraq (Bahrein)	4 NE	11/29 2185 R	07/25 R, 18/36 R	NDB, RSP, DF
10	**DHAHRAN**/Dhahran	3 SE	16/34 2139 —	06/24 —	RNG, NDB

* Elevation 1200 m

10 NORTH-EAST AFRICA



(Libya, Egypt, Sudan, Eritrea, Ethiopia, Somaliland)

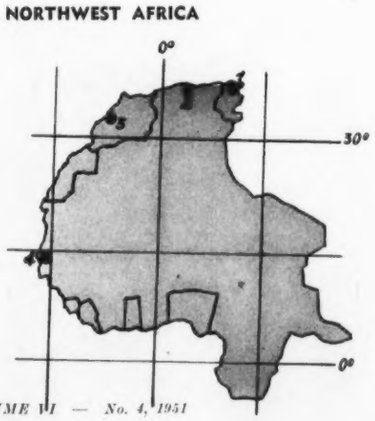


Control tower and terminal buildings at CAIRO/Farouk.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**TRIPOLI**/Castel Benito	14 S	18/36 2236 AR	05/23 AR, 11/29 AR	BABS, NDB, RSP, DF
2	**ALEXANDRIA**/Fouad	2 SE	18/36 1800 R	04/22 R, 09/27 R, 13/31 R	NDB, RSP
3	**CAIRO**/Almaza	6 NE	10/28 1730 R	05/23 R, 14/32 R	RNG, NDB, RSP, DF
4	**CAIRO**/Farouk	9 NE	13/31 2149 R	02/20 AR, 16/34 R, 18/36 R	RNG, NDB, RSP, DF
5	**KHARTOUM**/Civil	1 SE	18/36 1774 AR	05/23 R, 09/27 —, 14/32 —	BABS, NDB, RSP, DF
6	**ADDIS ABABA** (Ethiopia) *	3 SW	12/30 1691 —	———	NDB

* Elevation 2400 m

11 NORTHWEST AFRICA

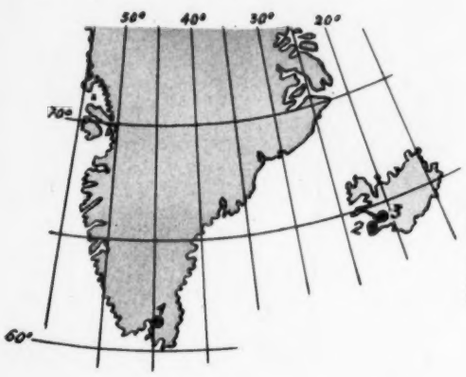


(Tunisia, Algeria, Morocco, French West and Equatorial Africa)

TUNIS/El-Aouina control tower follows the local style of architecture.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**TUNIS**/El-Aouina	4 ENE	12/30 1830 R	01/19 R, 03/21 R, 13/31 R	RNG, NDB, DF
2	**ALGER**/Maison Blanche	9 SE	10/28 2420 AR	05/23 R	RNG, NDB, DF
3	**CASABLANCA**/Cazes	3 SW	03/21 1826 AR	———	RNG, NDB, DF
4	**DAKAR**/Yoff	6 NW	12/30 2030 AR	04/22 R	ILS, RNG, NDB, RSP, DF

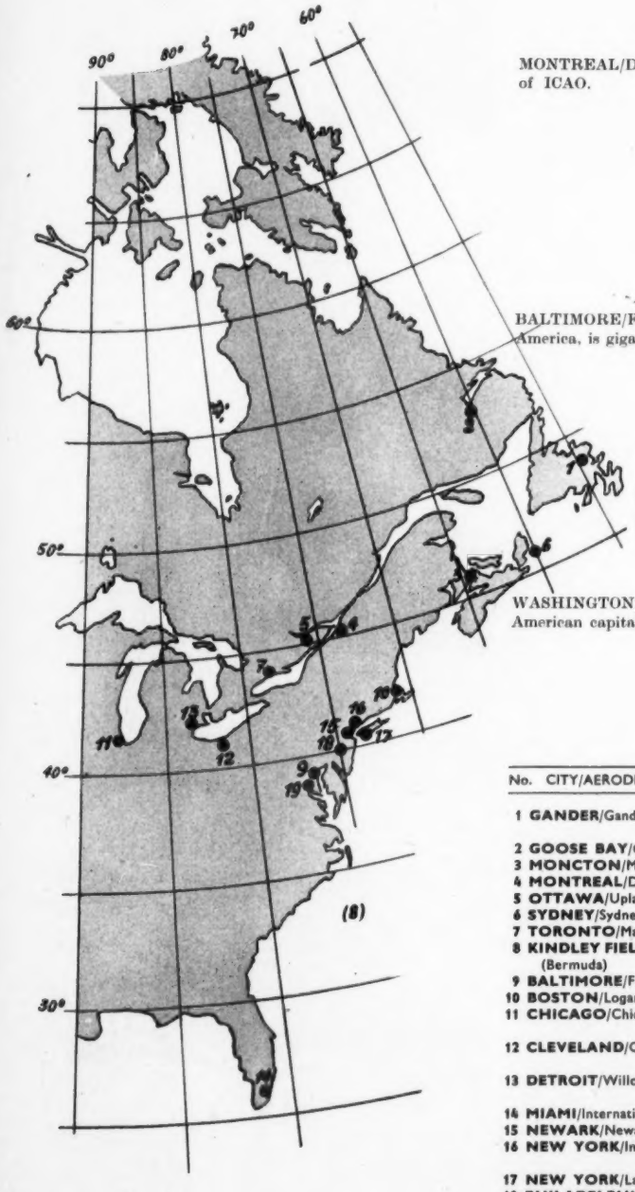
12 GREENLAND AND ICELAND



Reykjavik « Aerodrome Hotel ».

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**NARSARSSUAK**/Narsarssuak	44 Coast	08/26 1981 R	——	RNG
2	**KEFLAVIK**/Keflavik	2 SW	12/30 2591 R	03/21 R, 07/25 R, 16/34 R	ILS, GCA, RNG, NDB, RSP, DF
3	**REYKJAVIK**/Reykjavik	1 S	02/20 1436 AR	07/25 R, 14/32 R	RNG

13 EASTERN CANADA (INCLUDING NEWFOUNDLAND), EASTERN USA AND BERMUDAS



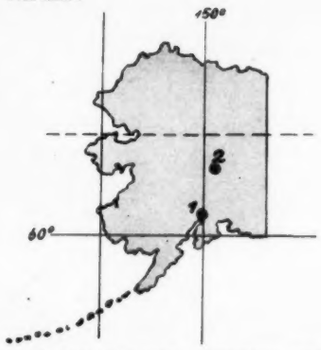
MONTREAL/Dorval, aerodrome for the Headquarters of ICAO.

BALTIMORE/Friendship, newest airport in North America, is gigantic.

WASHINGTON/National Airport, aerodrome for the American capital.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**GANDER**/Gander	35 ESE Botwood	09/27 1884 AR	05/23, 14/32 AR, 18/36 AR	GCA, RNG, NDB, DF
2	**GOOSE BAY**/Goose	—	17/35 1917 AR	05/23 —, 09/27 AR	GCA, RNG, NDB, DF
3	**MONCTON**/Moncton	4 E	11/29 1916 AR	02/20 AR, 07/25 AR	ILS, RNG
4	**MONTREAL**/Dorval	6 WSW	10/28 2134 AR	01/19 AR, 06/24 AR	ILS, RNG
5	**OTTAWA**/Uplands	4 S	17/35 1250 AR	04/22 AR, 12/30 AR	ILS, RNG
6	**SYDNEY**/Sydney (Can)	6 ENE	07/25 1524 AR	01/19 R, 14/32 R	RNG
7	**TORONTO**/Malton	15 NW	10/28 1829 AR	05/23 AR, 14/32 AR	ILS, RNG
8	**KINDLEY FIELD**/Kindley Field (Bermuda)	1 S St. George	12/30 2283 AR	01/19 R, 08/26 R	ILS, RNG, NDB, RSP, DF
9	**BALTIMORE**/Friendship	8 S	10/28 2880 AR	04/22 R, 15/33 R	ILS, GCA, RNG, VOR
10	**BOSTON**/Logan	1 E	04R/22L 3055 R	04/22 AR, 09/27 R, 15/33 R	ILS, GCA, RNG, VOR
11	**CHICAGO**/Chicago	8 SW	13R/31L 1747 AR	2×04/22 R, 2×09/27 R, 2×18/26 R, 13/31 R	ILS, GCA, RNG, VOR, NDB
12	**CLEVELAND**/Cleveland	8 SW	18/36 1830 R	3×05/23 AR, 10/28 R, 14/32 R, 18/36 R	ILS, RNG, VOR
13	**DETROIT**/Willow Run	19 WSW	04/22 2230 AR	2×09/27 R, 04/22 R, 14/32 R, 18/36 R	ILS, RNG
14	**MIAMI**/International	5 NW	09/27 2240 R	09/27 R, 12/30 AR, 17/35 R	ILS, GCA, RNG, VOR
15	**NEWARK**/Newark	2 SSE	06/24 2230 AR	01/19 R, 10/28 R	ILS, GCA, RNG
16	**NEW YORK**/International	11 SE	07/25 2500 AR	2×01/19 R, 04/22 AR, 07/25 AR, 2×13/31 R	ILS, GCA, RNG
17	**NEW YORK**/LaGuardia	5 SE	13/31 1770 R	04/22 AR, 09/27 R	ILS, GCA, RNG
18	**PHILADELPHIA**/International	6 SW	09/27 1610 AR	04/22 R, 12/30 R, 17/35 R	ILS, RNG, VOR
19	**WASHINGTON** (D. C.) National	2 S	18/36 2050 AR	03/21 R, 09/27 R, 15/33 R	ILS, GCA, RNG

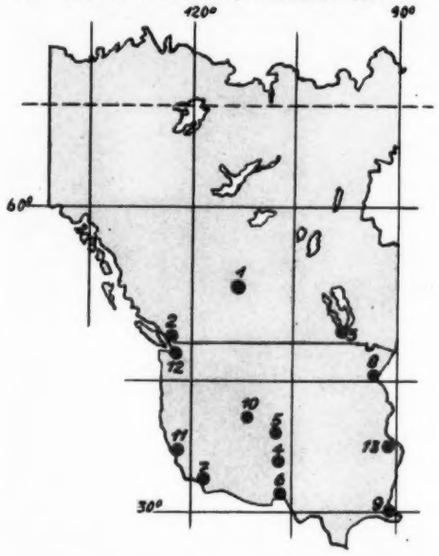
14 ALASKA

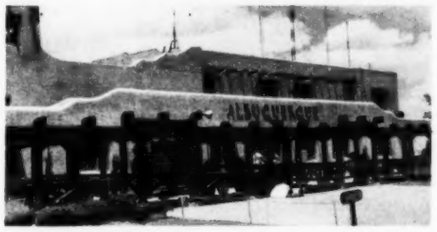


ANCHORAGE/Elmendorf, USAF base.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**ANCHORAGE**/Elmendorf	4 NE	05/23 2591 AR	15/33 AR	GCA, RNG, RSP, DF
2	**FAIRBANKS**/Ladd	3 E	06L/24R 2789 AR	06R/24L AR	GCA, RNG, DF

15 WESTERN CANADA, WESTERN USA

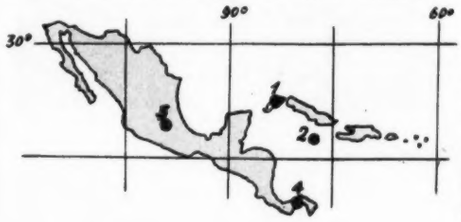


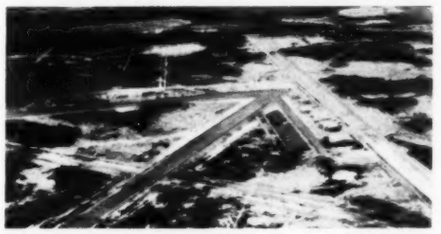


The terminal building at ALBUQUERQUE/Kirtland (New Mexico) is in Spanish style.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**EDMONTON**/Municipal	NW suburbs	11/29 1788 AR	03/21 AR, 15/33 AR	GCA, RNG
2	**VANCOUVER**/Vancouver	8 S	11/29 1576 AR	07/25 AR, 02/20 AR	ILS, RNG, DF
3	**WINNIPEG**/Stevenson	NW suburbs	13/31 1890 AR	18/36 AR, 08/26 AR	ILS, RNG, RSP, DF
4	**ALBUQUERQUE**/Kirtland	5 S	08/26 4000 R	03/21 R, 17/35 AR, 11/29 R	ILS, RNG, VOR, DF
5	**DENVER**/Stapleton	5 NE	08R/26L 2591 R	12/30 R, 17/35 AR, 08L/26R R, 03/21 AR	ILS, RNG
6	**EL PASO**/International	4 NE	08/26 2152 R	04/22 AR, 17/35 R, 12/30 R	ILS, RNG, VOR
7	**LOS ANGELES**/International	SW suburbs	07L/25R 1835 R	07R/25L AR, 11/29 R, 16/34 R	ILS, GCA, RNG
8	**MINNEAPOLIS**/St. Paul Internat.	4 S	04/22 1981 R	17/35 AR closed, 11/29 R, 08/26 R	ILS, GCA, RNG, VOR
9	**NEW ORLEANS**/Moisant	9 W	10/28 2131 AR	01/19 R, 14/32 R, 05/23 R	ILS, RNG, VOR
10	**SALT LAKE CITY**/Municipal	4 NW	16/34 2033 AR	14/32 R, 07/25 R	ILS, RNG, VOR
11	**SAN FRANCISCO**/San Francisco	8 S	10L/28R 2362 AR	10R/28L R, 01/19 R	ILS, GCA, RNG, VOR
12	**SEATTLE**/Tacoma	12 S	16/34 1859 AR	02/20 R, 11/29 R, 07/25 R	ILS, RNG, VOR
13	**ST. LOUIS**/Lambert	9 NW	06/24 1829 R	16/34 R, 12/30 R	ILS, GCA, RNG, VOR

16 CENTRAL AMERICA AND WEST INDIES



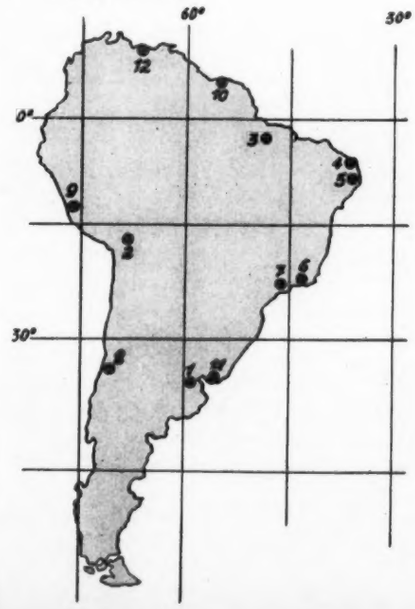


The airport at MEXICO CITY is among the highest in the world.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**HABAÑA**/Rancho Boyeros (Cuba)	8 S	05/23 1440 AR	13/31 —	NDB
2	**KINGSTON**/Palisadoes (Jamaica)	3 S	14/32 1615 R	09/27 R	NDB
3	**MÉXICO**/Central (Mexico)*	3 E	05R/23L 3048 —	05/23 —, 05L/23R —, 10/28 —, 14/32 —	RNG, NDB
4	**PANAMA**/Tocumén (Panama)	11 NE	03/21 2136 AR	———	NDB
5	**NASSAU**/Oakes Field (Bahamas)	2 SW	09/27 1829 —	03/21 —, 12/30 —	RNG, NDB

* Elevation 2240 m

17 SOUTH AMERICA

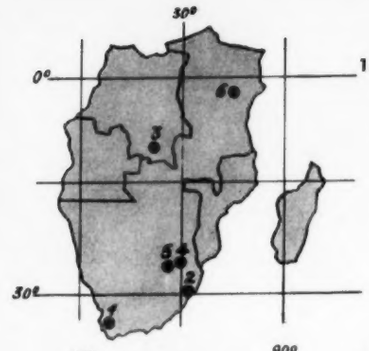


(Argentina, Bolivia, Brazil, Chile, Peru, Surinam, Uruguay, Venezuela)

BUENOS AIRES/Ministro Pistarini, South America's most modern airport.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**BUENOS AIRES**/Pistarini	14 S	10/28 2850 R	04/22 R, 16/34 R	ILS, NDB, RSP
2	**LA PAZ**/El Alto (Bolivia) *	3 W	... 3140 —	———	...
3	**BELEM**/Val de Cães	4 N	02/20 1829 AR	06/24 AR	RNG, NDB
4	**NATAL**/Parnamirim	8 S	16/34 2250 AR	12/30 AR	RNG, NDB
5	**RECIFE**/Ibura	5 S	15/33 1890 R	18/36 R	NDB
6	**RIO DE JANEIRO**/Galeao	in city	14/32 2375 R	———	NDB
7	**SAO PAULO**/Cangonhas	5 S	18/36 1400 —	14/32 —	———
8	**SANTIAGO**/Los Cerillos	4 SW	03/21 2000 —	———	NDB
9	**LIMA**/Limatambo	1 E	02/20 1982 —	16/34 —	NDB
10	**PARAMARIBO**/Zanderij	23 S	10/28 2134 —	03/21 AR	NDB
11	**MONTEVIDEO**/Carrasco	7 E	... 1740 R	two	...
12	**CARACAS**/Maiquetia	8 NW	08/26 1524 AR	———	NDB

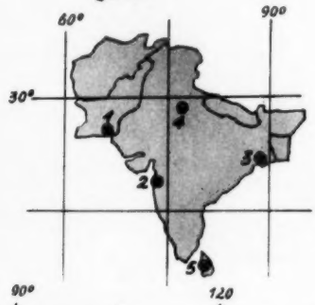
* Elevation 4100 m



18 SOUTH AFRICA (Union of South Africa, Belgian Congo, Kenya)

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**CAPETOWN**/Wingfield	4 E	02/20 1286 R	05/23 R, 14/32 R, 18/36 R	SBA, NDB, DF
2	**DURBAN**/Reunion	under construction			
3	**ELISABETHVILLE**/Elisabethville	3 N	13/31 1798 —	———	NDB
4	**JOHANNESBURG**/Palmietfontein	11 SE	17/35 1829 AR	04/22 —, 13/31 —	BABS, SBA, NDB, RSP, DF
5	**JOHANNESBURG**/(Pretoria) Jan Smuts	under construction			
6	**NAIROBI**/Eastleigh *	in city	06/24 2194 —	14/32 —	BABS, NDB, DF

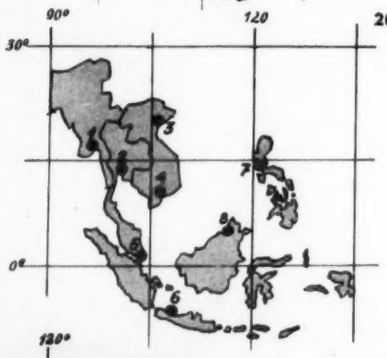
* Elevation 1640 m



19 PAKISTAN, INDIA, CEYLON

KARACHI/Drigh Road, the airport of Pakistan.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**KARACHI**/Karachi Civil	8 NE	08/26 2286 AR	———	RNG, NDB
2	**BOMBAY**/Santa Cruz	7 NE	05/23 1829 —	09/27 —, 14/32 —	BABS, RNG, NDB, RSP, DF
3	**CALCUTTA**/Dum Dum	15 N	01/19 1829 AR	———	BABS, RNG, NDB, RSP, DF
4	**DELHI**/Palam	5 SW	09/27 1829 —	05/23 —	BABS, NDB, RSP, DF
5	**COLOMBO**/Ratmalana (Ceylon)	8 S	04/22 1829 —	———	RNG

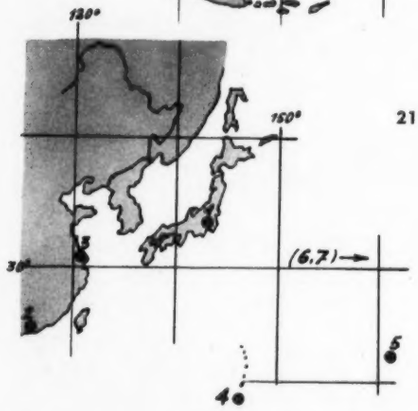


20 SOUTH-EAST ASIA

(Burma, Thailand, Indo-China, Malaya, Indonesia, British North Borneo, Philippines)

A DC-4 belonging to the Australian company QEA at VICTORIA/Labuan (British North Borneo).

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**RANGOON**/Mingaladon	7 N	07/25 1737 R	17/35 —	NDB, RSP, DF
2	**BANGKOK**/Don Muang	11 NE	03/21 1829 R	———	NDB, DF
3	**HANOI**/Gia-Lam	2 E	02/20 1315 —	12/30 —	NDB, DF
4	**SAIGON**/Tan-Son-Nhut	3 NW	07/25 1700 —	18/36 R	NDB, DF
5	**SINGAPORE**/Tengah	10 NW	01/19 1862 AR	———	NDB, RSP, DF
6	**DJAKARTA**/Kemajoran	2 NE	17/35 1768 R	08/26 R	RNG, NDB, DF
7	**MANILA**/Manila International	5 S	13/31 2423 AR	06/24 AR	RNG, NDB
8	**VICTORIA**/Labuan	1 N	... 1829 —	———	...



21 FAR EAST AND NORTH PACIFIC ISLANDS

The same QEA DC-4 at HONG KONG/Kai-Tak airport in the heart of the mountains.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**TOKYO**/Haneda	7 SE	15/33 2133 AR	04/22 R	GCA, RNG, NDB, DF
2	**HONGKONG**/Kai-Tak	2 NE Kowloon	07/25 1450 R	13/31 R	NDB, RSP, DF
3	**SHANGHAI**/Lunghwa	3 S	18/36 1829 R	10/28 —	GCA, NDB
4	**GUAM I.**/Agana	3 E Agana	06L/24R 2167 R	06R/24L R	RNG, NDB, DF
5	**WAKE I.**/Wake	—	09/27 2134 R	———	NDB
6	**MIDWAY I.**/Midway	—	06/24 2408 R	03/21 —, 15/33 —	NDB, DF
7	**HONOLULU**/Honolulu	4 NW	08/26 2347 AR	04R/22L R, 04L/22R R, 14/32 R	RNG, NDB, VOR, DF

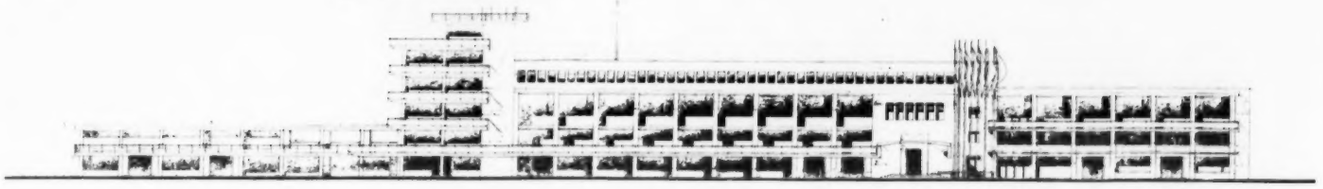
22 AUSTRALIA (INCLUDING TASMANIA), NEW ZEALAND AND SOUTH PACIFIC ISLANDS

Kingsford Smith Airport, SYDNEY.

No.	CITY/AERODROME	LOCATION	LONGEST RUNWAY	OTHER RUNWAYS	RADIO AIDS
1	**ADELAIDE**/Parafield	8 NE	08/26 2408 —	12/30 —, 17/35 —	RNG, NDB
2	**BRISBANE**/Eagle Farm	5 NE	08/26 1118 R	04/22 R, 12/30 R	RNG, NDB, DF
3	**DARWIN**/Darwin	3 NE	13/31 3048 R	18/36 —	RNG, NDB, RSP, DF
4	**HOBART**/Cambridge (Tasmania)	7 NE	10/28 1372 —	06/24 —, 14/32 —, 17/35 —, 12/30 —	RNG, NDB
5	**MELBOURNE**/Essendon	7 NW	08/26 1859 R	04/22 —, 17/35 R	RNG, NDB
6	**PERTH**/Guildford	5 NE	06/24 1829 R, 11/29 1829 R	17/35 R	RNG, NDB, DF
7	**SYDNEY**/Kingsford Smith	In City	04/22 1527 R	11/29 R, 16/34 —	RNG, NDB, RSP, DF
8	**AUCKLAND**/Whenuapai (N. Z.)	7 NW	04/22 2009 R	08/26 R, 13/31 —	RNG, NDB, RSP
9	**CHRISTCHURCH**/Harewood (N. Z.)	5 NW	02/20 1402 R	11/29 R	RNG, NDB, RSP
10	**WELLINGTON**/Paraparaumu (N. Z.)	15 NE	16/34 1477 AR	03/21 R, 12/30 —	RNG, NDB
11	**NANDI**/Nandi (Fiji Islands)	3 NE Nandi	03/21 2176 AR	09/27 R	RNG, NDB, DF
12	**NOUMÉA**/Tontouta (New Caledonia)	21 NW	11/29 1860 R	02/20 —	RNG, DF

Beirut International Airport

BY PIERRE PIVOT



Airport terminal building—runway side.

Beirut International Airport was officially opened to air traffic on 1st July, 1950.

The North-South runway was then complete, also a minimum of taxiways leading to the provisional apron, so that the landing area, though limited, was nevertheless coherent.

On this date the new international airport opened:—

—a direct service to Paris, operated by Air France,

—a service to New York via London, operated by Pan American Airways.

Five months later, in addition to those of the air transport companies already installed there, the aircraft of five large international companies regularly visited Beirut, connecting the Lebanese capital direct with New York, Hong Kong, Paris, Saïgon, London, Rome, Karachi, Stuttgart, Calcutta, New Delhi, Bangkok...

Today air traffic at Beirut uses both the old aerodrome at Bir Hassane and the new airport recently built in the dunes of Khaldé. This is however only a passing phase. The old aerodrome is to be closed as soon as work at the new airport is sufficiently advanced to enable the latter to provide all the services outlined below.

Landing area

Beirut International Airport has two landing and take-off runways and a complete system of taxiways and aprons, capable of carrying a wheel load of 45 tons.

The airport is situated about 5 miles from the centre of the town, at a height of 18 ft. and about 800 yds. from the Mediterranean coast.

The two landing and take-off runways both have the same characteristics: length, 7800 ft.; width, 195 ft. One of them runs north-south and is used for instrument landings, when landing and take-off are made towards the south. The other runs north-east/south-west. These runways formed a V in the original design, but in practice they were left separate, to facilitate ground operations.

The fuelling system for aircraft consists of a network of underground pipes, with a number of supply points in front of the terminal buildings.

Terminal Buildings

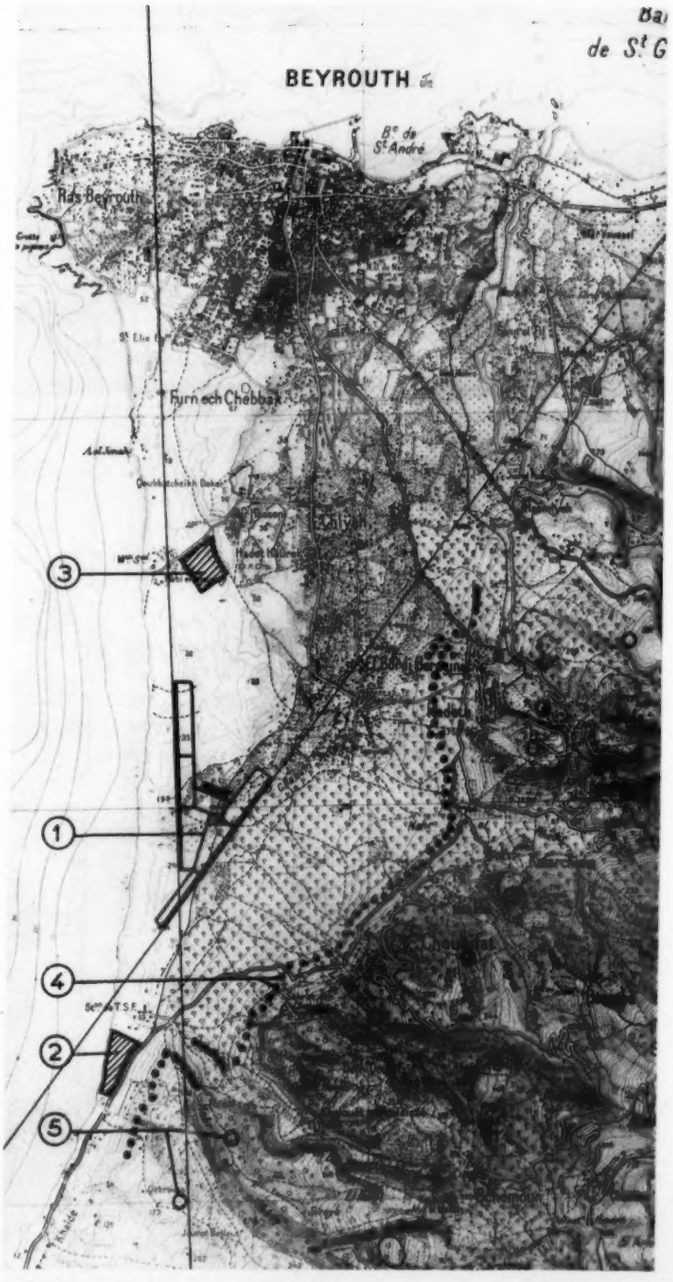
These consist primarily of three buildings in a line running approximately east-west.

The central block houses the general technical and traffic services and the two wings the Customs sheds.

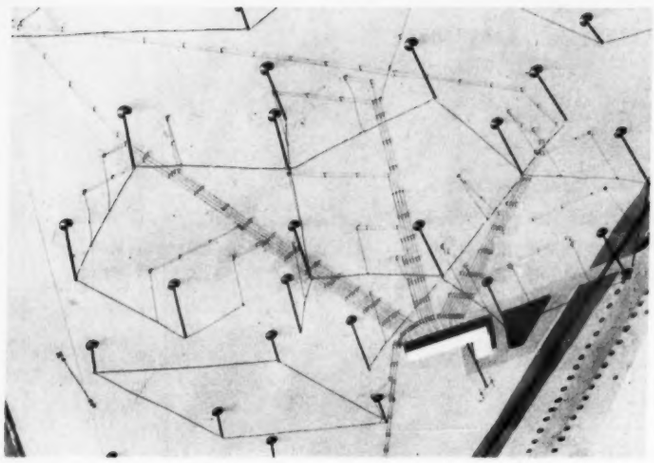
In elevation the main building is on two levels:

—high level, town side, reached by a ramp, a continuation of the airport road which runs straight out from the town (distance 4 miles). It houses waiting rooms, public restaurant, crews' restaurant, kitchens, etc.... the public facilities are on the same level in a wing;

—low level, runway side, comprising entrance hall, offices belonging to the various companies, a grill, ticket and passport offices etc.



1. Landing area
2. Transmitter
3. Receiver
4. Line of obstructions
5. Mountain lights



View of part of transmitter station.

This arrangement means that:

—baggage and passenger circuits can be kept separate,

—all installations connected with the handling of baggage can be arranged on the runway level,

—there is free access from one Customs shed to the other,

—all Customs facilities can be used either for incoming or outgoing passengers,

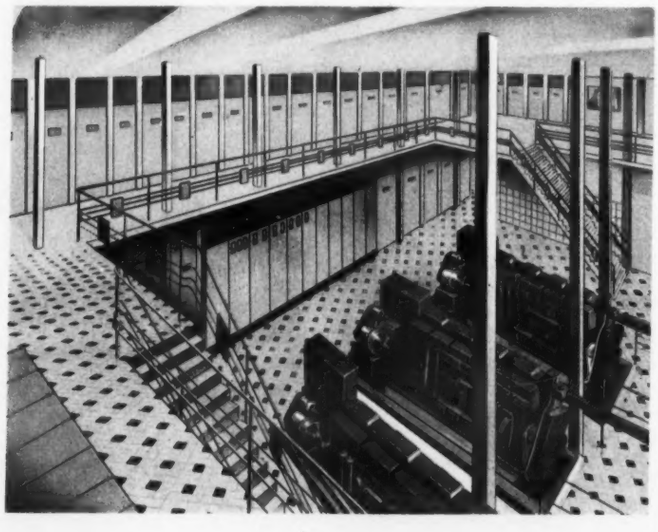
—a public terrace can be provided overlooking the landing area, in addition to the restaurant terrace.

The technical and administrative services are grouped in a block the design of which combines the architecture of offices with that of the larger, central block and thus expresses the dual nature of the services provided by all airport terminal buildings.

This block houses the manager's offices, the runways office, meteorological office, central telecommunications office, air traffic control office, etc.... finally, crowning the whole, the control tower proper.

The airport's central electrical installations are housed in a two-storey building on the other side of the road running alongside the main block of the terminal buildings, on the town side. Its two storeys are on a level with the basement and the ground floor of the main buildings. Its main room has a volume of 2,500 cu.m. and is dug out of the ground under the ramp leading to the main hall of the terminal building. The ground floor, arranged in gallery style

Electrical sub-station—airport emergency centre (drawing).



inside, houses the H.T. compartments, and the basement the emergency electric generators (with a total power of 600 KVA) and the L.T. equipment. For safety reasons the electricity supplied from the Beirut grid comes in by two 5,500 volt H.T. cables.

Air Navigation Aids

The position of the airport, between the sea and the mountains, in a region where climatic conditions are good, has necessitated the provision of extensive navigation aids.

Radio aids:—

—a MF radio beacon, using a vertical transmitting aerial, in St. Georges Bay,

—two low power radio markers, one for waiting and one for approach,

—two D/F stations, one VHF, the other HF,

—instrument landing system, complete with localizer, glide-path and markers.

Visual aids:—

—landing area lighting;

—line of approach in white lights, Slope Line type, 900 m. long;

—area where low flying is prohibited, land side, marked by line of red lights at intervals of 50 to 150 m. over a distance of 12 km. This line is backed by more powerful lights on the hills overlooking the Khaldé plain.

For safety reasons this lighting is fed from transformers placed at intervals along a H.T. loop which largely follows the line of lights and runs from the terminal buildings from which it takes its power.

—Identification lights, searchlights etc.

Telecommunications

The central telecommunications office is in the terminal buildings. All the messages which the various offices wish to send out are collected here by means of a local teleprinter network, and all messages concerning the airport which come in from outside are distributed by the same means.

This central office is duplicated on the one hand by a group of operator's posts for manual radio communications, and on the other by a set of stands for automatic radio communications, from which a transmitter and a receiver station, the former 2½ miles to the south and the latter 2 miles to the north, are remote-controlled.

In both cases the buildings are of solid construction and are raised somewhat above ground floor level. They provide light spacious accommodation for the radio equipment and other services, such as maintenance, stores, watch room, electric sub-station and emergency centre, etc....

In view of their distance from the landing area it has been possible to instal the aerials near the buildings.

In the great majority of cases the transmitters and receivers work on a single pre-set frequency, the radio personnel's chief task being to keep watch.

Recently the Lebanese civil aviation authorities have decided to convert some of the manual systems into radio teleprinters, thus establishing the first radio teleprinter connection for air transport between the Middle East and Western Europe.

Beirut international airport therefore continues worthily in the tradition of this cross-roads of the world which the Lebanon owes to its exceptional natural position and to the energy and enterprise of its people.

Radio at Rangoon

BY DR. B. J. O'KANE

The new Air Traffic Control Building at Mingaladon Airport, Rangoon.

As a result of the increasing importance of Rangoon as the gateway to the Far East, the Burmese Government decided to inaugurate a scheme for bringing Mingaladon Airport up to ICAO Class A standards for international airports. As an essential part of the scheme a new Air Traffic Control building, which will provide adequate space for all services, has been built. Although the present radio installations are functioning satisfactorily, International Aeradio Ltd., who are the operating agents for the Government, have taken the opportunity of bringing it up to date and incorporating the latest techniques in this field.

The Rangoon installation provides for Aerodrome, Approach and Area Control and Flight Information Centre. The Aerodrome and Approach Controllers work side by side in the tower and the Area Controller and FIC Controller side by side in another room of the new Air Traffic Control building. The point-to-point operators are in a further room adjacent to the FIC. On the other side of the FIC is the Meteorological Office. There is no radio equipment in any of these rooms, all units being remotely controlled. The radio equipment is installed in the equipment room below the tower and is mounted in specially designed cabinets which, besides allowing a tidy installation, prevents unauthorised adjustments.

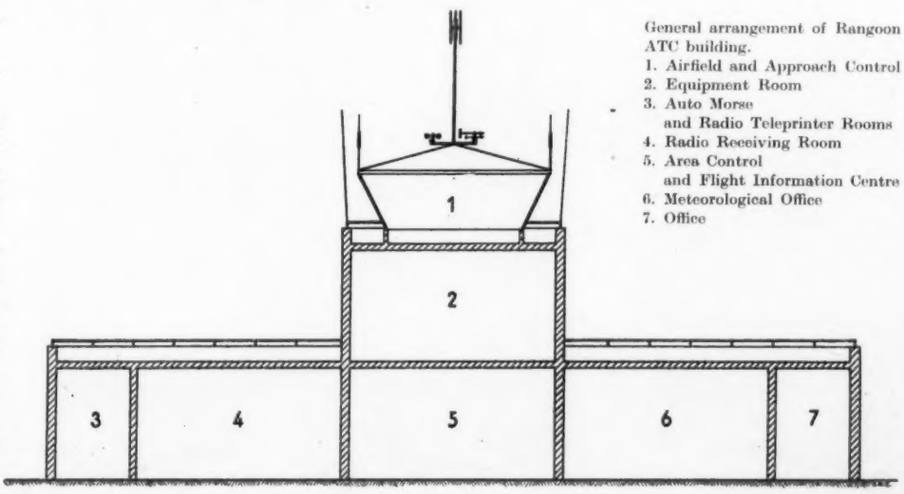
The facilities provided for Aerodrome Control are:—

VHF R/T Ground/Air (Two channels); HF R/T Ground/Air (One channel); VHF R/T Surface Movement (One channel); Intercommunication (10 Lines); Telephone to Private Branch Exchange.

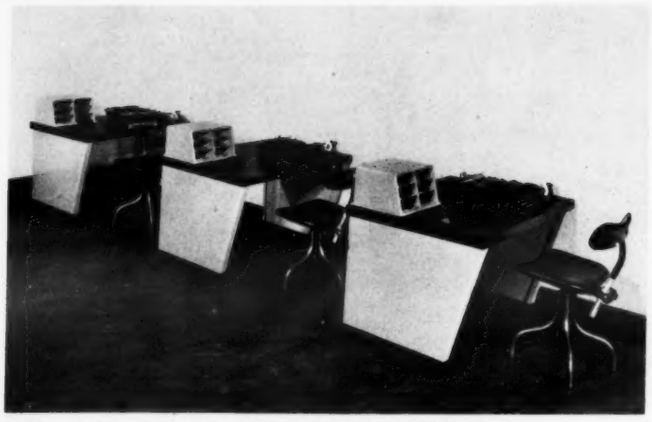
The Approach Control facilities are similar to Aerodrome Control, and the layout of the two desks is identical. Between them is an additional unit on which is mounted the remote meter for the VHF D/F, the MF beacon and DME monitor lamps and the display panel with the flight progress card holders giving details of aircraft movements. The two grilles at the side of each desk cover the loudspeakers and the centre back panels contain the clock, barometer, and wind speed and direction indicators. On the left are the R/T control buttons and the intercommunication switchboard. The R/T microphones can either stand on the desks or be suspended from the roof thereby keeping the desk clear. The telephone handsets are coloured for ease of identification. The R/T control buttons are of a special design which is of interest. They are of translucent plastic on which the frequency or service is engraved. An incoming signal unmutes the appropriate receiver (all receivers are muted to cut out unnecessary noise) and this lights a small bulb inside the button thereby indicating which channel is calling. The controls have a double action; when one is pressed to transmit, the first part of the movement mutes the receiver to prevent "howling round" and the last part switches on the transmitter. This also lights the indicator bulb showing that the transmitter is working. There is a "broadcast" control button which operates any pre-selected combination of transmitters. Thus for example one VHF and the HF R/T could be selected. A "crash" button for emergency alarm is fitted above the intercommunication switchboard. Under the glass panels in the centre of the desks are maps of the aerodrome and approach areas. An airfield lighting control panel, similar to the intercommunication panel, will be fitted on the right hand side.

The Area Control and FIC desks are less elaborate. The Area Controller has two VHF (one emergency channel) and one HF R/T channel for ground to air communication plus an HF R/T point to point channel to adjacent Air Traffic Control Centres, intercommunication, telephone (PBX) and a repeater for the VHF D/F. There are rather larger display panels for aircraft movements in the Area Control Zone.

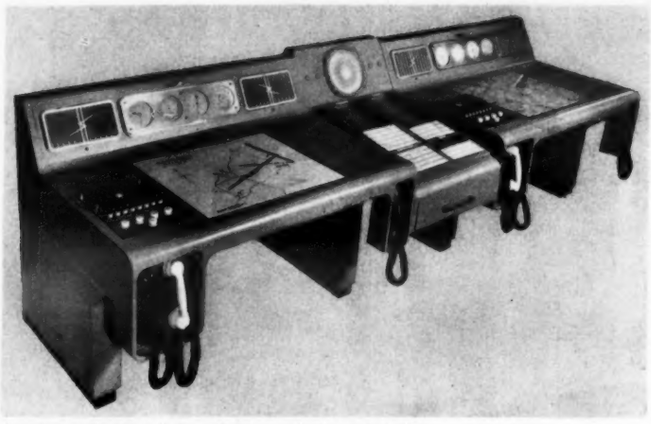
The FIC controller has a rotating drum to hold the flight information messages of the aircraft under his jurisdiction. He has no direct communication channels with the aircraft but has two HF R/T point to point channels to adjacent Flight Information Regions for emergency use. He can also operate the VHF emergency channel. Normally his messages are passed either by the HF R/T communicators sitting near him or by the W/T operators in the adjoining radio receiving room. At the FIC desk there is room for a clerk who handles the



General arrangement of Rangoon ATC building.
1. Airfield and Approach Control
2. Equipment Room
3. Auto Morse and Radio Teleprinter Rooms
4. Radio Receiving Room
5. Area Control and Flight Information Centre
6. Meteorological Office
7. Office



Radio receiving room : three of the W/T operators' positions.



Aerodrome Control (left) and Approach Control desks.

message chits. The HF R/T operators take down all incoming messages directly on signals typewriters so that there is a permanent record available. Messages from the W/T air-guard channel operators are passed through hatches from the radio receiving room.

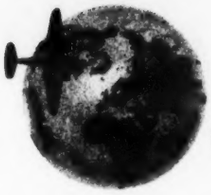
The primary consideration in the layout of the radio receiving room is again the elimination of all unnecessary controls. The introduction by the International Telecommunications Union of closer tolerances on transmitter frequencies has removed the need for W/T operators to have access to receiver tuning controls and the operators have only a small remote control unit for RF gain and BFO and of course a key and headphones. In certain positions a dual control unit is provided so that a watch can be kept on two channels. There are twelve operators' positions, a supervisor's desk and a traffic clerk's desk. Single channel crystal controlled receivers are used throughout for both R/T and W/T, all the receivers being mounted in cabinets in the equipment room. Only one receiver aerial for the air ground services is used; this feeds into a series of wide band amplifiers (aerial multicouplers). The outgoing circuits are connected to a specially designed rack-mounted control unit and then via a multi-pair cable to the remote transmitting station. A frequency meter and crystal monitor are included in this rack.

In the two small rooms leading off the main radio receiving room are the morse auto-transmitters for the Meteorological broadcasts and the teleprinter equipment. At present the only radio teleprinter circuit is on a VHF link between the airport and Rangoon. This link can also be used as an emergency telephone channel. Some of the W/T circuits will later be converted to radio teleprinter operation.

The nerve centre of the whole installation is of course the equipment room, although for the reasons outlined earlier there is very little to see other than a number of closed cabinets. There are thirteen of these and two contain the VHF and HF R/T receivers with their associated ancillary units for feeding the telephony and channel indicating signals to the Aerodrome, Approach and Area control positions. These ancillary units are specially designed for use in a standardised R/T system and permit great flexibility in the layout. Two cabinets contain all the standby R/T transmitters and receivers. There are two 50 watt HF transmitters, two 15 watt VHF transmitters and their associated receivers and ancillary units. A switch panel enables any combination of main or emergency transmitters and receivers to be selected. Other cabinets contain the five wideband HF amplifiers, each of which has ten outlets, and the thirty-eight HF R/T and W/T single-channel receivers. At present there are six long range HF R/T channels but others can be converted if required. The receiver outputs are fed to another rack-mounted control unit and thence to the receiving room. Any receiver can be connected to any operator's position at the supervisor's request. In addition there is the master console for the VHF D/F which feeds the two remote meters.

Only a brief outline of such a comprehensive installation can be given in the compass of a short article, but it should provide some indication of what can be achieved by taking advantage of recent advances in radio technique.

In the Radio Equipment Room : all equipment is remote-controlled from the operating rooms. Equipment is mounted in 13 closed cabinets which allows a tidy installation and prevents unauthorized adjustments. *Left :* Cabinet containing two VHF and two HF receivers and their associated ancillary equipment. *Centre :* Control unit. *Right :* One of the standby cabinets containing VHF and HF transmitters and receivers.



What's in the Air?*

SUBSIDIES DECLINED WITH THANKS...

Last month we reported that air transportation's record business was for the first time continuing unabated through the 1950/51 winter season (*Interavia* No. 3/1951, p. 155). The annual reports of American Airlines and United Air Lines, since published, make an impressive addition to this picture.

American Airline's net profit for 1950 not only reached the record figure of $10,400,000, an increase of 45% over the previous year, but it also rose from quarter to quarter. A report published at the end of February by the New York brokers John H. Lewis & Co., shows that AA's operational receipts increased by 59%, 116% and 500% in the second, third and fourth quarters of 1950 respectively.

United Air Lines report a net profit of $6,429,723 (compared with $2,249,405 in 1949), and their President, W. A. Patterson, states in his survey of the year that the firm, like other leading American companies, had not received any hidden subsidies in the form of mail payments. The UAL had been paid $7,837,000 for the transport of mail, whereas the American postal authorities had received $23,065,000 for the same quantity.

TWA's receipts for the last quarter of 1950 were $1,500,000, and Ralph Damon, the President, is expecting an increase in traffic by about 12%-18%.

This is not to say that American air transportation can yet free itself entirely of State assistance. But even if one swallow doesn't make a summer, it cannot be denied that there are already "several swallows" to be seen in the American skies. Recently published statistics for American air transportation as a whole show that taxable income rose by 47% in 1950 and that 19.7% more freight ton/miles were flown than in 1949. Goods transported in connection with the Korean airlift of course contribute largely to this increase in freight traffic.

No wonder the companies can expand their air fleets. UAL, for example, who is expecting no fewer than 20 new DC-6s in spring, 1951, has announced that it has also placed an order for thirty 340-A "Convair-Liners", whilst a medium-sized company like National Airlines has ordered 16 Douglas DC-6Bs, to be delivered before the end of the year. And Juan T. Trippe, President of PAA, is said to have negotiated for the supply of de Havilland "Comet" jet transports for PAA's subsidiary, Panair do Brasil, during his recent visit to Britain.

*

Although the ground gained by European air transportation is relatively modest, the successes scored here must nevertheless not be completely ignored. The timetables conference of the European members of IATA held in Paris in February decided to increase the summer time-tables by roughly 20%. But if European traffic continues to increase at the present rate it might even happen that future demand may exceed supply. British Overseas Airways Corp. already reports an increase of 22% in passenger traffic for 1950 (18% in freight, 6% in mail, 7% in baggage).

The general prospects of British air transport were discussed by Peter Masefield, Chief Executive of BEA, in a lecture to the Institute of Transport at the end of February. He stated that since its inception in 1919 British air transport had cost the nation £60,500,000. This loss can and must be made good by profits in the future. — BEA's traffic figures seem to indicate that the corporation are on the right road: in 1950 losses were reduced by 37% compared with 1949 (from £1,500,000 to £953,239), and in spite of an increase of 366 in personnel the operational output per head rose by 28%.

*

On the other hand Italian air transportation has not yet been able to surmount the crisis caused by faulty organization. But even here there is a ray of hope. The Italian Parliament is considering a bill to open a credit of 60,000 million lire for the State finance institute (Instituto per la Ricostruzione Industriale = IRI). At the same time the Italian Cabinet decided to entrust the IRI with the reorganization of air transportation. The first step was to dissolve the government-owned Linee Aeree Transcontinentali Italiane (LATI) and suspend operations by the Italo-British company, Alitalia, and by ALI-Flotte Riunite. The Italo-American company, LAI, is to continue as before, for the time being.

AIR ARMAMENTS IN THE EAST

At the ceremonial opening of the Supreme Soviet which took place in the Kremlin's Marble Hall on 6th March 1951—in the presence of Stalin, the Russian Cabinet, Soviet Marshals Voroshilov, Bulganin, Konyev, Cherkov and the whole diplomatic corps—Russian Finance Minister Arseney Sverev presented the 1951-52 budget. Of the total expenditure of 451,600 million roubles, 96,400 millions, or 21.3%, are for armament—17,000 million more than during the previous year (defence estimates 1950-51 : 18.5%). Nothing is known to date on the distribution of these credits among the three armed services. Nevertheless it is unlikely that the Red Air Force and Naval air service will be treated in niggardly fashion.

A U.S. Air Force Information Service report dated 1st March, 1951, estimates the present strength of the Red Air Force at 18,000 first line aircraft and annual production as roughly 8,500 military aircraft of all types, including 3,500 MiG-15 jet fighters. (In the House of Commons Wing Commander Lucas mentioned 7,500 jet aircraft a year). According to this report Soviet air defence is at present concentrating on three main tasks:

1) Arctic air fleet for defence against attacks from the Polar region,
2) local defence air fleet and A/A units to protect industrial centres,
3) mobile units totalling some 1000 MiG-15 jet fighters, to reinforce weak points in the air defence screen.

As regards the bomber fleet the American report still maintains the old theory that the Red Air Force has only relatively weak offensive forces (primarily 800 bombers of the obsolescent Tupolev type, as is known, a copy of the Boeing B-29 "Superfortress").

* Extracts from INTERAVIA AIR LETTER, daily international news digest, in English and French. All rights reserved.

The first RCAF unit to go overseas for training in peacetime. The 421 Red Indian Squadron has gone (without aircraft) to work with British units at Odiham fighter station, in southern England.

It is not only between air and ground that conversion problems arise. The conversion of Canadian dollars into pounds sterling seems to bewilder the newly-arrived crews of RCAF's 421 Squadron.

The Swedish paper "Stockholms Tidningen," however, reported from Moscow early in March that a large number of test flights have recently been made in all parts of the Soviet Union by long-range bombers of up-to-date design. One of these bombers, said to be designated Il-26, is stated to have flown non-stop from Moscow to the Siberian coast in the autumn of 1950, carrying a pick-a-back aircraft and reaching a cruising speed of 280 to 295 m.p.h. The Russian designers Ilyushin and Tupolev are said to have been concerned in the development of this prototype.

Though no details are known of type, designer's name, range, etc., it seems certain that Russian industry has been working for months on the development of strategic bombers.

This supposition is further strengthened by the report that the Red Air Force has 44 air bases on the Siberian coast opposite Alaska, at least 15 of them designed for heavy bombers.

In June, 1950, according to "Jane's Fighting Ships," the Red Fleet put the aircraft carrier "Sovietsky Soyush" into commission, the first vessel of a new class (35,000 tons) which is to have a speed of 30 knots and be equipped for rocket firing. During recent months two (?) more aircraft carriers have been launched.

The heads of the Russian armed services are by no means taking American and British rearmament lightly. — The appointment of General Eisenhower has been countered by the nomination of Marshal Bulganin as "Chief of Operations on the Russian Atlantic Front."

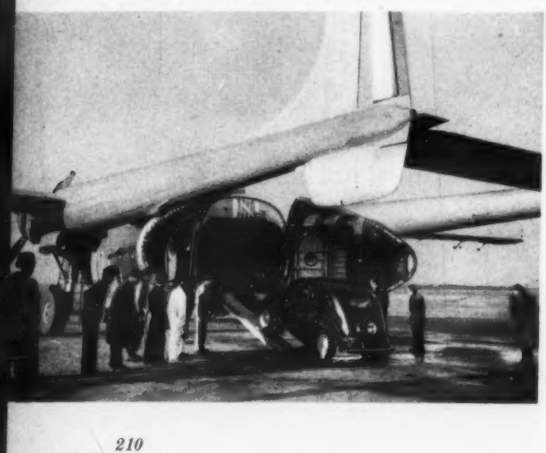
BUT THE WEST IS NOT IDLE EITHER

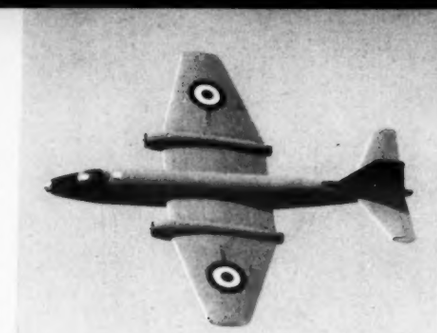
When presenting the air estimates in the House of Commons, Arthur Henderson, Secretary of State for Air, stated that the RAF is to become Great Britain's most important defence arm. Its strength has already increased by approximately 50% since March, 1948. The first four-engined jet bomber is to make its first flight quite soon (no design details are yet available). It is to be faster than the "Canberra" and of course considerably superior in range and payload. The RAF units in Germany are to be reinforced during 1951 and placed under the orders of the Supreme Commander of the Atlantic forces, as are also the light bomber units stationed in Great Britain. Radar equipment from World War II is being taken out of "mothballs," and brought fully up-to-date.

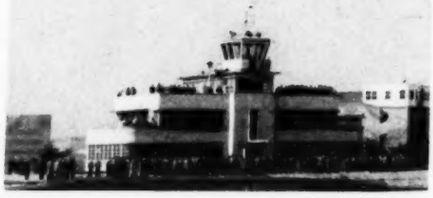
The additional armament credits of 50,000 million lire for 1951-52 and 200,000 million for Italy's three-year rearmament plan requested by Defence Minister Randolfo Pacciardi have been granted by the Italian Parliament. Air armaments are to have the following share: —

	1950-51	*1951-52*	*1952-53*
	(in thousand million lire)		
Air Force	22	22	11
Civil Defence	3	4	3

The French counterpart to the American Fairchild "Packet" military transport, the Nord 2501 "Noratlas" built by SNCA du Nord. An initial order has been placed for 160 of these aircraft, which are powered by two Bristol "Hercules 739" engines.







Glenn L. Martin Co. of Baltimore has obtained a licence to build the English Electric "Canberra." The aircraft is seen here on a demonstration flight at the factory.

The Defence Minister also announced that Italy has received almost 200,000 million lire worth of armaments from the USA during the first year of military aid. Deliveries are to be still further increased during the coming year. The Italian Air Force now has all the units allowed it under the Peace Treaty fully equipped. "Several dozen" airfields are to be equipped during the current year to take jet aircraft.

And during his stay in Ankara Thomas Finletter, the American Air Force Secretary, agreed to send 100 American jet fighters to Turkey during the next three years.

AIRCRAFT CONSTRUCTION IN THE SUNNY SOUTH...

The design and construction of the CASA 201 "Alcotan" twin-engined transport by *Construcciones Aeronauticas S.A.* marks a new phase in Spanish aircraft production. The CASA 201 is the first civil transport aircraft to be built by the Spanish industry. — The first prototype of the CASA 201 made its maiden flight in February, 1949, and flight testing of a second has been started. A third prototype is said to be nearing completion.

Stephane P. Thouvenot, formerly Director of Air Navigation and Transportation in the French Transport Ministry, has been appointed Deputy Director General of IATA in Montreal.

It is now reported that Construcciones Aeronauticas are working on another transport type, the *CASA 202 "Halcon."* This is an all-metal low-wing monoplane with retractable undercarriage, for a crew of three and 15 passengers. Two Spanish-built Elizalde engines with a take-off power of 775 h.p. and a rated output of 750 h.p. will give the "Halcon" a cruising speed of 186 m.p.h.; service ceiling is said to be 24,770 ft., or 9,040 ft. with one engine stopped.

...AND IN THE FROZEN NORTH

Development of the "Finnmark" twin-engined amphibian by the Norwegian firm *Norsk Flyindustri* continues. A modified prototype, the 5 A-II, is now being tested. Compared with the original 5A-I version the present model has a longer nose and a hull designed according to modern hydrodynamic principles. The tail unit has also been modified, and the two Pratt & Whitney R-1340 "Wasp" 610 h.p. engines are shortly to be fitted with three-bladed v.p. propellers. A combination undercarriage (wheels and snow-skids retractable into the stub floats) designed for the "Finnmark" by the British firm of Dowty Ltd., is shortly to be fitted, thus making this aircraft particularly suited to operations in the far north.

NEW SUPER-BOMBERS ON THE WAY

In the autumn of 1947 the *Boeing Airplane Co.* began development of the Boeing B-52 heavy bomber. This aircraft was to have high speed combined with long range and was generally regarded as the successor to the Convair B-36. Apart from an indication that propeller turbines would be used, no details were given.

Two years later it was stated that the B-52 would have eight jet engines instead of the propeller turbines. It was also announced that the USAF had ordered two prototypes.

Fairey Aviation Co. Ltd. has also recently developed experimental delta-wing aircraft. The *Fairey "Delta" F.D. 1* (single seater, span 19 ft. 6½ in, length 26 ft. 3 in.). At present the F.D.1 is fitted with a Rolls-Royce "Derwent" jet engine, but rocket engines are to be used for later high-speed tests.

About a year ago it was gathered that the two XB-52 prototypes had been completed, but that quantity production was not envisaged. The fate of the B-52 appeared to be sealed.

No reasons were given for dropping the B-52. Rumours became current in aviation circles that the USAF intended to replace the B-36 bomber by guided missiles. One of the reasons for the suspension of work on the B-52, however, was most probably the lack of sufficiently powerful jet engines at that time. (True, work was going on on several high-powered engines, but most were still in the experimental stage). It must be remembered that the B-52 was to have a gross weight of over 400,000 lbs.!

Today the picture is very different. Several high-power American jets have now got far beyond the experimental stage and are ready for quantity production (in some cases this has already begun). In addition, thanks to close collaboration with the British aero engine industry, there are also British jet engines available, such as the Armstrong-Siddeley licence for Wright Aeronautical Corp., Rolls Royce licence for Pratt & Whitney Aircraft Division and so on. It is largely because of this development in the aero engine industry that interest in the B-52 has re-awakened. In any case the USAF recently announced that the B-52 was to go into quantity production and the prototype would be flight tested before the end of the year.

The final version of the Boeing B-52 is to have eight Pratt & Whitney J-57 jet engines of 9000 lbs. thrust. Gross weight would be in the region of 350,000 lbs. A range of around 6000 miles, with a cruising speed of 400 m.p.h. is expected (in cruising flight four of the eight engines are stopped).

The USAF has changed its plans not only as regards the Boeing B-52 but also as regards the *Convair B-36*. This aircraft is not now to be replaced by the B-52, but both types are to be used side by side. A clear indication of this—Convair has been asked to accelerate the construction of a prototype version of the B-36 with swept wing and eight jet engines (General Electric J-47s), to be known as the *B-36F*.

The Meteorological Teleprinter Service

By Dr. P. WÜSTHOFF

It is an incontestable fact that aviation is and always will be dependent on the weather. Whatever technical advances may be made it will never be possible to dispense with a meteorological service for aircraft. The system of providing weather information to safeguard flying is based on a world-wide weather reporting network and the meteorological service has the responsible task of providing weather observations and meteorological forecasts rapidly and reliably.

The chief means of communication in the weather reporting service are radio and teleprinter.

Weather stations throughout the world daily receive a multitude of weather reports by radio, so as to get an accurate picture of the behaviour of the weather on the earth's surface and of the vertical structure of the atmosphere.

Although a great many weather observations and reports still come in by radio, increasing use has been made during the past 15 to 20 years of teleprinters. For example between 1936 and 1945, the former German Reich Meteorological Service used an extensive " weather circular network ", which proved extraordinarily successful.

Shortly after the end of World War II the German meteorological service re-established its own weather teleprinter network in the U.S. Zone. This started work on 1st October, 1946, and has since been considerably expanded. This network connects up all the weather offices and German aviation weather observers in the Zone. In Frankfurt there is a central teleprinter exchange, which joins up the so-called weather office network and the aviation weather observation network. This meteorological teleprinter system in the U.S. Zone is connected with the weather stations in the French Zone via Stuttgart and Frankfurt, and a teleprinter line between Bremen and Hamburg provides a connection with the teleprinter network of the German meteorological service in the British Zone.

Fig 1. contains a diagram of the teleprinter connections in Western Germany as on 10th March, 1951. This meteorological teleprinter network is used not only for the collection and dissemination of weather observations from the individual meteorological areas, but also, and to an even greater extent, for the transmission of reports (surveys, forecasts and topographies) and collective weather messages to the various weather stations.

There are several reasons why the meteorological service gives preference to teleprinter communications. The system is economical in staff, is three or four times as fast as radio and, last but not least, messages are received in clear, concise form. This last point is of inestimable value in the interpretation of weather reports for the use of aviation, where speed is essential. Another advantage is that teleprinter traffic

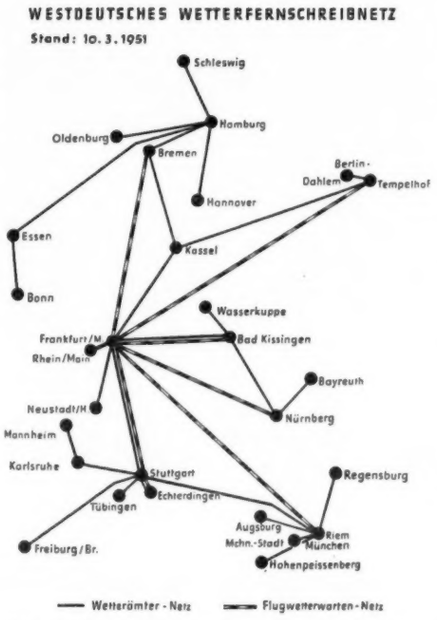


Fig. 1 : West German meteorological teleprinter network.

is unaffected by atmospheric disturbances or local radio-electric interference.

It was doubtless because of all these reasons that the organisation of a " European weather ring " was begun within a few months after the Allied invasion of Western Europe. This " ring " now connects up all the important meteorological centres in Western Europe. The main stations of the Western European system are in Paris, Dunstable (near London), Bad Eilsen (near Hanover) and Rhein-Main (Frankfurt).

In essentials the Western European meteorological system consists of four parallel current circuits each operated independently. Connected to this basic network are the De Bilt Meteorological Institute in Holland (for reception only) and the Brussels Meteorological Institute in Belgium. Zurich and Rome are connected to Paris, the central office of the German Meteorological service in the U.S. Zone has three connections (Paris, Dunstable and Bad Eilsen), which run from Frankfurt to Bad Kissingen. From Bad Eilsen there are connections via Quickborn, near Hamburg, with Copenhagen, Oslo and Stockholm, which are thus included in the basic network. It is also planned to connect up Helsinki with Stockholm.

The task of the central stations in Paris, Dunstable, Bad Eilsen and Frankfurt is to disseminate weather information from all parts of Europe, North Africa and North America on the international weather ring. This work is split up among the four stations as shown in map 3. Dunstable is responsible for reporting on the weather in the British Isles, Iceland, Italy, Spain and Portugal ; Bad Eilsen for Scandinavia, Greenland, Belgium and Holland and the British and Russian Zones of Germany. Frankfurt takes care of South-Eastern Europe and Russia and the French and American Zones of Germany. Finally Paris sends reports on the weather in France and North Africa and a selection of reports from North America which come in on a teleprinter line from New York via Santa Maria to Paris.

The foregoing merely gives an outline of the meteorological teleprinter service as it

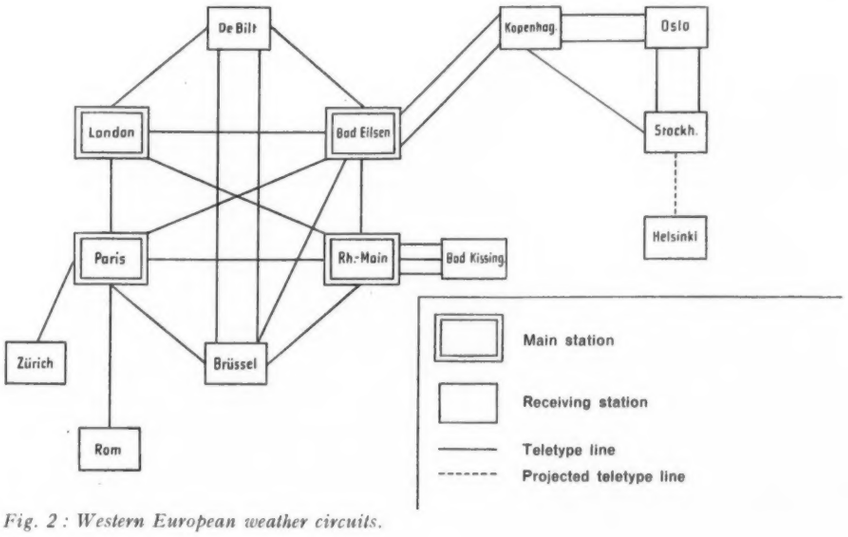


Fig. 2 : Western European weather circuits.

exists today, without, however, going into present-day problems.

In future the radio teleprinter service will perhaps be used to a much greater extent than hitherto for the transmission of weather information.

Doubtless the transmission of weather maps, such as was organized on a number of lines by the former Reich Meteorological Service during the War, will play an important part in the future weather reporting system, and perhaps television too.

However, the problems of the meteorological service are not only of a technical nature. Considerable difficulties are often experienced in the organization of weather observation stations, *i.e.*, in building up the actual weather reporting network. It is universally known how valuable to the meteorological service in general are regular weather reporting centres at sea, for example. In the Atlantic and the North Sea alone there are at present thirteen "weather ships" of various nationalities, which send out weather reports every three hours according to internationally accepted principles. The Pacific has at the moment three "floating weather stations" to provide regular weather observations. It is planned to increase this number to seven. It can scarcely be imagined what natural obstacles have to be overcome in the operation of some of the most vital weather stations. For example the "Ice Centre" station which was re-established in Greenland (70.5° N, 40.4° W) in 1949 lies 9680 ft. above sea level on the plateau of the tundra. The lowest temperature measured there was minus 64.8° C (—85° F). But it is stations such as these that are particularly valuable in meteorology.

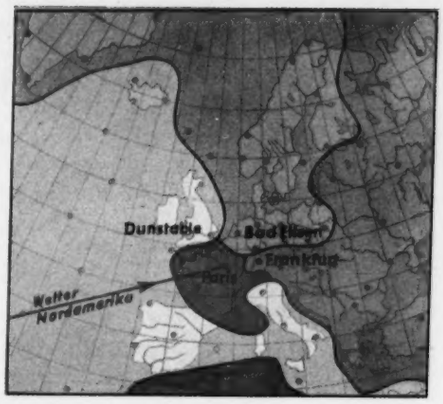


Fig. 3 : Distribution of work among the central stations in the international circuit.

Although the problems of the weather reporting network strictly speaking do not come within the realm of the meteorological service, some reference must nevertheless be made to them. The meteorologist who ten years ago was satisfied with a weather map showing principally the ground observations from Europe and the Eastern Atlantic, now requires a world-wide network covering the whole of the Northern hemisphere and giving not only ground and ships' observations but also measurements of the vertical structure of the atmosphere.

Finally it should be remembered that the first task of the meteorological service is the rapid and reliable provision of meteorological observations and measurements and the punctual transmission of its own weather messages and meteorological reports. It is an indisputable fact that the teleprinter has always proved highly suitable here—for both the international exchange of weather information and the meteorological safeguarding of aviation.

ICAO-Abbreviations for radio facilities *

a/c	Aircraft
ACC	Area control centre
A/G	Air ground communication station
a.m.	Morning
APP	Approach control
ATC	Air traffic control
BABS	Beam approach beacon system
BS	Broadcasting station
Chan.	Channel
CON	Consol
CTA	Control area
CTR	Control zone
DF	Direction finding station
DF/CS	Direction finding control station
E	East or Eastern
Ex.	Except
FIC	Flight information centre
FIR	Flight information region
FIS	Flight information service
Fri.	Friday
GCA	Ground controlled approach
↓	Other frequencies available
GEE	Gee
H	Hour(s)
HDF	High frequency DF
H24	Continuous day and night service
HJ	Sunrise to sunset (day service)
HJ +_	Sunrise to_minutes after sunset
_−HJ+_	_minutes before sunrise to_minutes after sunset
_+HJ+_	_minutes after sunrise to_minutes after sunset
HN	Sunset to sunrise (night service)
HX	No specific working hours
IFR	Instrument flight rules
ILS	Instrument landing system
IM	Inner marker
L	Compass locator _ if necessary the letters I (inner), M (middle) or O (outer) placed after "L" will indicate location.
MDF	Medium frequency DF
MER	Above mean sea level
MET	Meteorological broadcasts
MM	Middle marker
Mn.	Minutes
Mon.	Monday
N	North or Northern
NDB	Non-directional radio beacon
OM	Outer marker
O/R	On request
O/R-_	On request_minutes' notice
P	Pulse emission
PAR	Precision approach radar
p.m.	Afternoon
Rec.	Receive(s)
RNG	Radio range
RSP	Responder beacon
RTF	Radio telephony
S	South or Southern
Sat.	Saturday
SBA	Standard beam approach
Sun.	Sunday
Thur.	Thursday
Tue.	Tuesday
TWR	Aerodrome control
VAR	Visual-aural range
VDF	Very high frequency DF
VFR	Visual flight rules
VOR	VHF Omni-directional radio range
W	West or Western
Wed.	Wednesday
WX	Weather broadcast
Z	Greenwich mean time
&	And

* In the European-Mediterranean region, as on 23rd February 1951.

Very High Frequency Omni-Directional Range Navigation

By Richard Watson Thwing, Bendix International Division — Bendix Aviation Corporation

When radio navigation engineers were confronted with the problems of atmospheric and man-made interference in the operation of air navigation automatic direction finding equipment, they didn't throw up their hands in despair and conclude that further progress was impossible. If all-weather flight was to become a reality, they knew that automatic direction finding had to be a primary aid.

They have found in the broad band of frequencies between 30 and 3,000 megacycles (the VHF and UHF bands) the static-free, uncrowded media which, when utilized in a new system of direction finding, solves many of the pilot's problems.

One of these systems of VHF navigation, using the portion of the VHF band from 112.0 mc. to 117.9 mc., is the Omni-directional Range, more properly known as the Visual Omni-Range (VOR). It supplants the old 4-course radio range as an aid to pilot orientation in terminal areas. It will also add millions of miles to the world's airways by eliminating the necessity of flying a zig-zag course along intersecting courses of successive 4-course ranges and by permitting multi-lane airways. It provides multiple courses to or from the ground station along which a pilot may fly by keeping a needle centered, and in conjunction with distance measuring equipment (DME) and the Course Line Computer, will inform the pilot of his exact position at all times.

The heart of the VOR is the ground station which emits a cardioid-shaped radiation pattern which revolves in space at a speed of 1800 RPM (30 cps). The azimuth angle of an aircraft from the ground station is determined by measuring the phase angle between this rotating signal and a fixed reference signal also emitted by the ground station.

This measuring equipment is the nerve system of VOR and is carried aboard the aircraft. It receives the omni-range signals and interprets them on special cockpit dials.

A picture of all the equipment that may be used in a complete system, including several variations of some units, is shown in Figure 1.

The antenna, normally mounted on top of the aircraft, resembles the swept-back unit, sometime called the deer or ramshorn, so familiar on modern aircraft and utilized for Instrument Landing Systems (ILS).

The receiver, except for its power supply, is contained in a long narrow case, commonly called a standard one-half ATR form factor. All connections to the unit, except for the antenna, are made automatically when the receiver is placed in its shockmount. There are no operating controls at the receiver, nor are there adjusting controls on the outside of the case where they might be turned by unauthorized personnel.

The receiver may be tuned to 280 channels spaced 100 kc. (.1 mc.) apart throughout the band of frequencies 108.0 to 135.9 mc. This allows reception or utilization of the following services or facilities:

Frequency Band in Megacycles	*Type of Service*
108.0 to 111.9	Runway Localizer (either TONE or PHASE comparison emission)
108.3 to 110.3	VHF Two-Course Range
111.0 to 111.9	Weather Broadcasts
112.0 to 117.9	Omni-Range
118.0 to 121.9	Tower
122.0 to 131.9	Commercial Communications
132.0 to 135.9	Military Communications

MN-69A OMNI-BEARING INDICATOR
MN-97A OMNI-BEARING SELECTOR-INDICATOR
ID-48A FLIGHT PATH DEVIATION INDICATOR
MN-82E OMNI-BEARING SELECTOR
MN-72A RADIO-MAGNETIC INDICATOR
MN-81G REMOTE CONTROL
MN-93A REMOTE CONTROL
MN-85B VHF RECEIVER WITH MR-74DA MOUNTING BASE
MN-81D REMOTE CONTROL
MN-81C REMOTE CONTROL
MN-94B POWER SUPPLY AND AMPLIFIER WITH MR-84A MOUNTING BASE AND MN-69A OMNI-BEARING INDICATOR
MP-53B POWER SUPPLY
MP-65B POWER SUPPLY WITH MR-83A MOUNTING BASE
MP-60A CONVERTER
MN-89A AMPLIFIER IN MM-43A HOUSING MR-82A VIBRATION MOUNTING BASE
MR-78C ANTENNA RELAY
MS-192A VHF NAVIGATION ANTENNA

Fig. 1: Airborne VOR equipment, type Bendix NA-3.

Inside, the assembly is broken down into four (4) integrated sections. These sections may be separated from each other in this manner, which makes servicing easier. The four sections consist of the following :

R.F. Head :	Contains the complete radio frequency sub-assembly.
I.F. Chassis :	Contains the intermediate frequency and audio amplifier circuits.
Monitor Chassis :	Contains the ingenious circuits which allow 280 crystal-controlled channels with only 34 crystals along with the tuning drive motor for the R.F. Head.
Main Frame :	Contains navigational circuits and connections for interwiring the other sections.

The R.F. Head consists of a one stage tuned R.F. amplifier and a heterodyne mixer which feeds a 6.950 mc. signal to the I.F. and audio chassis. The R.F. Head also contains a local oscillator, frequency quadrupler and an isolation amplifier. All stages, except the isolation amplifier, are gang-tuned by a motor driven capacitor.

The I.F. and audio chassis accept the 6.950 mc. signal from the R.F. Head and pass it through a three stage double superheterodyne I.F. amplifier. The output is connected to two diode detectors, one of which feeds through a noise limiter to the audio amplifier. The other detector feeds a common navigational amplifier. This amplifier is connected to both the phase comparison and the 90/150 cycle tone comparison navigation circuits.

The monitor chassis' purpose is to control the frequency of the receiver's local oscillator and to control electronically the tuning capacitor drive. Switches select the proper crystals for the megacycle and tenth megacycle steps. A discriminator controls the reactance tube in the R.F. Head. The output of the monitor discriminator is also fed to a low pass filter, motor control amplifier and relays which control the tuning motor.

The main frame contains the navigational circuits. The output of the I.F. and audio chassis is connected to band pass filters, thence amplifiers and finally to the comparator circuits, etc. These will be described later relative to the instruments they operate with.

To control the receiver and to select the desired frequency, it is not necessary to search for the correct tuning. In place of the usual tuning dial, there is a simple decade switch which is calibrated directly in frequency in megacycles, shown in Figure 2. If, for example, it is desired to receive on 133.5 mc., it is only necessary to set the outer dial until the figures '33' appear under the '1' on the face of the dial. The inner or small knob is turned until .5 appears under the 133.

The circuits inside the receiver do the rest and quickly, accurately the receiver is ready to receive on the selected frequency. To conserve space on the panel, it is also possible to locate the volume control knob on top of and concentric with the small frequency knob. An ordinary toggle switch may also be mounted on the control panel to allow selection of either TONE or PHASE localizers when flying in areas where both types are in operation.

When it is desired to receive ordinary voice communications, it is only necessary to set the frequency selector dial to the correct frequency as listed in the facility chart. These frequencies are between 118.0 and 135.9 mc. An antenna selector relay chooses the correct type for navigation and communications, *i.e.*, a horizontally or vertically polarized unit. The output to the headphones may be either taken directly from the receiver or through an isolation amplifier distribution system such as the Bendix MI-32 and/or Bendix MS-92 units.

To utilize the equipment on TONE or PHASE comparison localizers, it is necessary to add an indicating instrument to the system. This instrument is the Course Deviation Indicator, Figure 3, formerly called the Cross Pointer Indicator. This instrument is familiar to all who have become even slightly acquainted with the ILS System. Once again, all that is necessary is to select the correct frequency at the Control Panel and when the aircraft is within range of an operating ILS localizer facility, the vertical needle of the Deviation Indicator will deflect to the right or left of the center position, depending upon the aircraft's location with respect to the runway. Naturally, the TONE-PHASE toggle selector switch will have to be placed in the correct position for the facility in use. Operation or flying of PHASE comparison localizers is carried out in the same manner as for the more common TONE systems. The horizontal needle is operated by a separate Glide Slope Receiver, as has been common practice.

In order that use may be made of the VHF two-course ranges, the equipment is operated exactly as for the localizers. These two-course ranges are more properly known as Visual-Aural Ranges (VAR) as they make use of both visual indications on the Deviation Indicator and aural signals heard through the headphones. The combination of these two allows positive orientation with respect to the range station.

Fig. 2 : The frequency selector in the Bendix NA-3 airborne VOR equipment has three windows. The top and middle window show the whole numbers of the reception frequency in mc/s. (set by means of the milled outer dial), and the bottom one the decimal figure (set by inner knob).

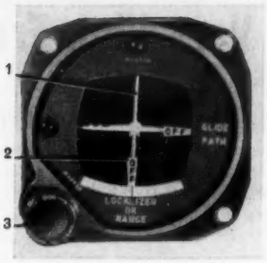


Fig. 3 : Course deviation indicator, with ILS Glide Slope pointer.

1 — Vertical pointer
2 — Flag alarm
3 — Marker beacon indicator lamp

To take advantage of the many improvements in navigation found in the Visual-Omni Ranges (VOR), there is added to the previous equipment, an instrument called the Omni-bearing Selector (OBS). This is shown in Figure 4.

The combination of the equipment so far described provides what is known as Minimum Instrumentation.

As a start towards the understanding of how to utilize VORs, let us consider the procedure involved in taking a bearing on one of the stations. First, as always, it is necessary to select the desired station's correct frequency on the control panel. For use with VOR stations, the TONE-PHASE switch should be in the PHASE position. Next, rotate the Course Set knob until the vertical needle of the Deviation Indicator becomes centered. The bearing read at top of the OBS will be either the magnetic bearing TO or FROM the station depending upon the indication appearing on the small TO-FROM indicator. This TO-FROM indication shows position only and does not show whether the aircraft is headed towards or away from the station without making reference to some magnetic heading indication. If it is desired to know the reciprocal of the determined bearing, it is only necessary to actuate the shutter knob and the reciprocal will appear. At the same time, the TO-FROM indication will change to the opposite from that which had been showing.

If the position of the aircraft is known, it is possible to plot a magnetic course on an aeronautical map to the desired station. This course is then set up on the Omni-bearing Selector and the aircraft flown by referring to the vertical needle of the Deviation Indicator in exactly the same manner as when flying a localizer.

If at any time, the Flag Alarm should show on the Deviation Indicator, it is an indication that something is wrong either with the ground station equipment or the airborne equipment and the indications of heading, bearing, etc. should not be relied upon or used.

Typical instrument readings are shown in Figure 5.

For those interested, we shall try to explain, briefly, what the OBS instrument does. We have stated earlier that the VOR stations emit two signals varying in their electrical phase relationship with respect to azimuth. The circuits inside the receiver have also shifted the reference signal so that it has a fixed 90° phase relationship with the variable signal and split the reference signal into two voltages that have a 90° phase relationship to each other. This two phase output is fed to the fixed windings of a manually-operated phase shifter. This manually-operated phase shifter with its calibrated scale is the Omni-bearing Selector. The rotor of the OBS will produce a voltage that will have a phase relationship to the input voltages in exact accordance with its angular position. The output of the rotor winding is connected to a phase comparator circuit, actually a bridge, where it is compared with the variable voltage. Therefore,

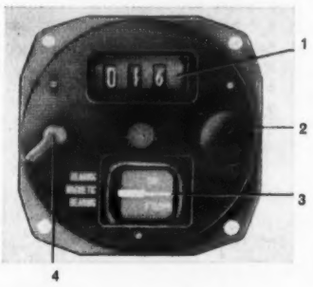


Fig. 4 : Omni-bearing Selector.

1 — Selected course indicator
2 — Course set knob
3 — TO-FROM indicator
4 — Shutter knob

when the output of the rotor is a voltage that has a phase relationship to its input equal to the phase relationship between the original variable and reference signals, the actual relationship of the voltages in the comparator will be either 0° or 180°. The output of the comparator will be zero under this condition and therefore the Deviation Indicator to which it is connected will read or indicate in the center.

Due to the 90° phase shifts as outlined above, there exists a possibility of ambiguity. To operate the TO-FROM or ambiguity indicator, the shifted reference signal is merely shifted another 90° and compared with the variable phase in a simple comparator circuit. In this circuit, the sum of the two voltages will be large if they are in phase and small if they are 180° different. This voltage is connected to rectifiers and resistors so that the meter in the circuit will either read full scale in one direction or the other.

As we have mentioned earlier, the standard forms of air navigation by radio have included a large utilization of automatic direc-

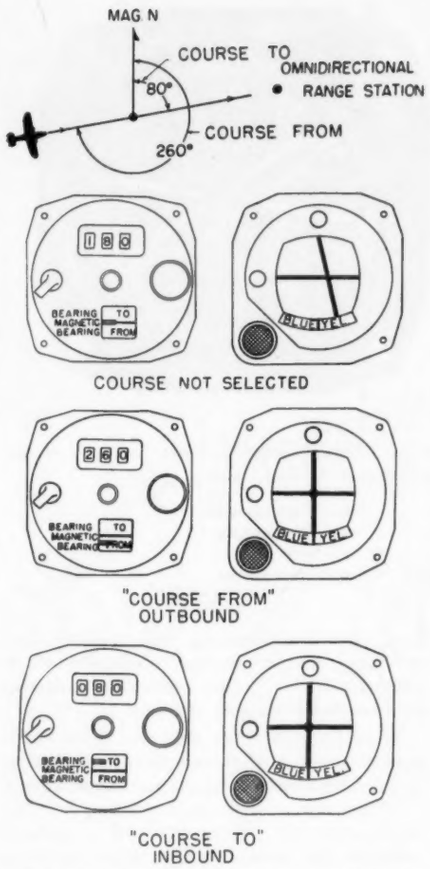


Fig. 5 : Typical readings on the Omni-bearing Selector MN-82 and Flight Path Deviation Indicator ID-48A.

tion finders (ADF). The pilots, therefore, are very used to navigation with relative heading type of presentation. This same system may be incorporated in the VHF ODR installation by combining the VOR information already present, using minimum instrumentation, with the compass heading. The combination of these two, it is easy to see, will be the position of the station tuned in, relative to the plane's nose or heading.

A synchro instrument is required to electrically combine heading and VOR bearing to actuate the pilot's indicator. The instrument that performs this combining function is known as the Omni-bearing Indicator (OBI).

The rotating scale read against the pointer indicates continuously and automatically the omni-bearing on which the aircraft is flying (Fig. 6). This type of presentation is usually not used for navigation as it is much more precise to fly a particular omni-bearing by referring to the Deviation Indicator as explained earlier. For this reason, the Omni-bearing Indicator is usually mounted in the radio rack instead of on the instrument panel.

It will be recalled that the Omni-bearing Selector employed a manually-operated rotor or phase shifter. The Omni-bearing Indicator employs a two phase motor which is connected to the phase comparator through a DC amplifier and saturable transducer. This allows the motor to rotate whenever there is not the required 90° phase difference to establish coincidence with the phase difference between the reference and variable signals. The motor rotates until the 90° phase difference is established and stops the rotor in that position. This allows the rotor always to seek and hold the correct point. Attached to the gear train inside the instrument is a differential syncro generator. This generator combines the compass heading fed in from the Flux-gate system with the omni-bearing information from the receiver and feeds the resultant to the Radio Magnetic Indicator.

The Radio Magnetic Indicator is simply an improved version of the common azimuth or ADF indicator. The improvement lies in the fact that the outer scale or compass card is continually driven from Flux-gate system which serves as a repeater for the Flux-gate Compass. This instrument is shown in Figure 7.

The Radio Magnetic Indicator furnishes the following information :

1. Heading of the aircraft as read on the scale against the lubber line.
2. Magnetic bearing of the aircraft relative to the station or the direction of the station relative to the heading of the aircraft, depending upon which end of the pointer is referred to.

The procedure of flying and navigating with the Radio Magnetic Indicator is so well known and commonly used that it is not felt that time should be spent describing the

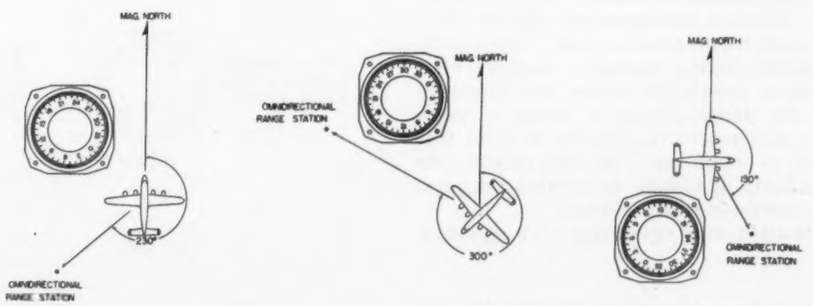


Fig. 6 : The Omni-bearing Indicator readings are independent of aircraft heading.

procedures. Some typical readings as shown on the R.M.I. are given in Figure 8.

The technical operation of the Radio Magnetic Indicator is very simple. The information fed from the Omni-bearing Indicator is connected to an autosyn motor which revolves a pointer. The compass card or outer scale is rotated by a two phase motor which is connected to the Flux-gate system through a separate amplifier. This amplifier is required to step up the weak signals generated by the Flux-gate transmitter so they will be powerful enough to drive the motor. In the standard R.M.I., there are the autosyns to which the pointers are connected. There is also the two phase motor that rotates the outer scale. The entire unit is hermetically-sealed against dust, moisture, etc., which could be injurious to the delicate mechanisms.

The combination of all the equipment so far described, constitutes what is known as maximum or full instrumentation.

Space on the instrument panel of modern day aircraft is sometimes rather limited. Inclusion of the Deviation Indicator on the instrument panel is a standard procedure due to the importance that has been placed on ILS. However, to add the Omni-bearing Selector and an ADF type Indicator may well be impossible due to the space limitations.

To overcome this difficulty, and for the even greater reason of grouping the instruments all together, so that the pilot will not have to shift his eyes all over the panel to read the navigational instruments, the three-in-one unit was developed. The unit's proper name is Omni-bearing Selector-Indicator. Included are facilities for cross pointer (deviation) indications, magnetic heading indications and an omni-bearing course selector. The instrument is shown in Figure 9.

In view of the fact that we have described all of the individual instruments that the Omni-bearing Selector-Indicator replaces, we shall instead describe the unit in detail and attempt to show its use in flight problems.

When flying on ILS Systems, only the vertical and horizontal needles are used. There is, however, a difference in that the needles are pivoted so that they move linearly, instead of being pivoted on one end. This has proved to make reading of the needle indications easier and less confusing.

For flying VOR ranges, the real value of the instrument becomes easily realized. Instead of having to operate the Omni-bearing Selector and watch it and the Deviation Indicator simultaneously, the two functions are together in one place. This greatly simplifies taking bearings. Further, when flying a preselected course and approaching the station, instead of having to watch two instruments, the eyes of the pilot only need to watch one. In this manner, the possibility of missing the overhead point at the station is greatly reduced.

In addition to omni-range position indications, the Omni-bearing Selector-Indicator provides relative heading indications when fed data from a remote indicating compass such as the Flux-gate System.

The relative heading indicator is the small pointer pivoted at the center of the instrument. Associated with it are scales at the

Fig. 7: The Radio Magnetic Indicator of the airborne VOR equipment.

1 — Fiducial marker
2 — Rotating card
3 — Rear pointer
4 — Front pointer

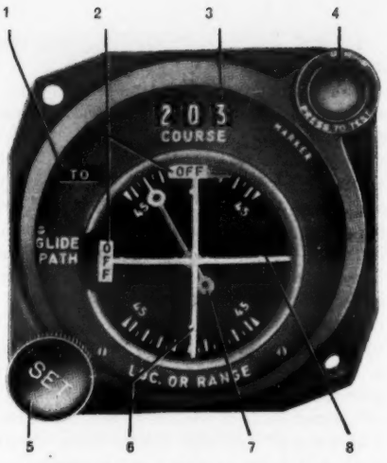


Fig. 9: The Bendix Omni-bearing Selector-Indicator (type MN-97A) gives readings of selected course to or from the beacon (QDM or QDR bearing), deviation from selected course and relative bearing to selected omni course. It also includes a glide slope pointer and light indicator for signal beacon reception.

1 — TO-FROM indicator
2 — Flag alarm
3 — Selected course indicator
4 — Marker beacon lamp
5 — Course set knob
6 — Vertical pointer
7 — Relative heading indicator
8 — Horizontal pointer

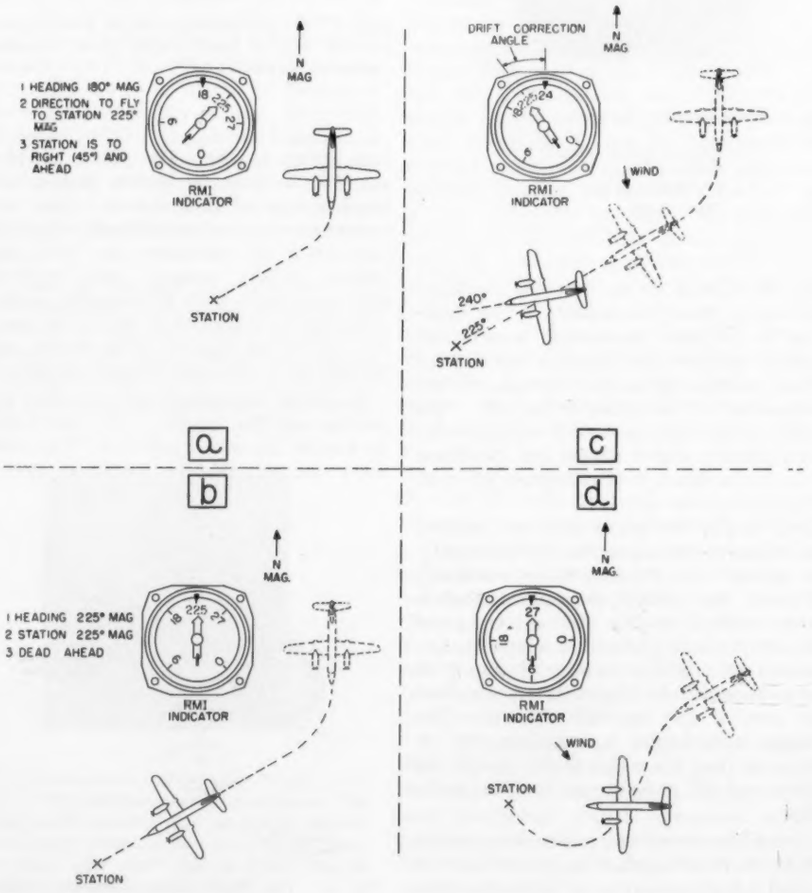


Fig. 8: Typical readings on the Radio Magnetic Indicator MN-72.

top and bottom of the indicator, which are calibrated in five degree steps, out to 45° on each side of center or zero point. This indicator shows the magnetic heading of the aircraft with respect to the omni-range or magnetic course set up on the course selector portion of the instrument.

It is believed that the best way of becoming acquainted with the operation is to study the typical indications as shown in Figure 9.

It will be noted that in keeping the head of the heading pointer and the Deviation Indicator together throughout the approach to the desired course we have accomplished a perfect asymptotic course and that it has not been necessary to bracket or compensate for over-shoot. The passengers should appreciate this as it eliminates the sometimes violent manœuvres associated with bracketing.

We have mentioned that flying an ILS System is the same as when using the normal Deviation Indicator. When, however, the Omni-bearing Selector-Indicator is included in the installation, we are able to have heading information as outlined above. It is only necessary to set up on the Selected Course Indicator, a course numerically equal to the runway's magnetic heading. Once again, we are able to achieve a smooth asymptotic approach to the localizer course without the need of manœuvres normally required in bracketing a localizer. This, in itself, is a safety factor in that it does away with extensive manœuvring of the aircraft during the approach procedure.

The instrument complement, consisting of the Omni-bearing Selector-Indicator instead of the separate Omni-bearing Selector and Deviation Indicator is known as intermediate instrumentation.

Technically, there is not any great difference in the Omni-Bearing Selector Indicator than in the individual units that it replaces. The only operation not previously covered is that of the relative heading indicator. An Autosyn installed in the instrument has its outer case or stator assembly manually rotated through a gear train connected to the course selector knob which also operates the manual resolver. Connections to the autosyn windings are made to the Flux-gate or Remote Indicating Compass system. The rotor assembly has mounted upon its shaft, the relative heading pointer.

If, for example, the aircraft is flying at 0° magnetic, the Flux-gate Compass and its

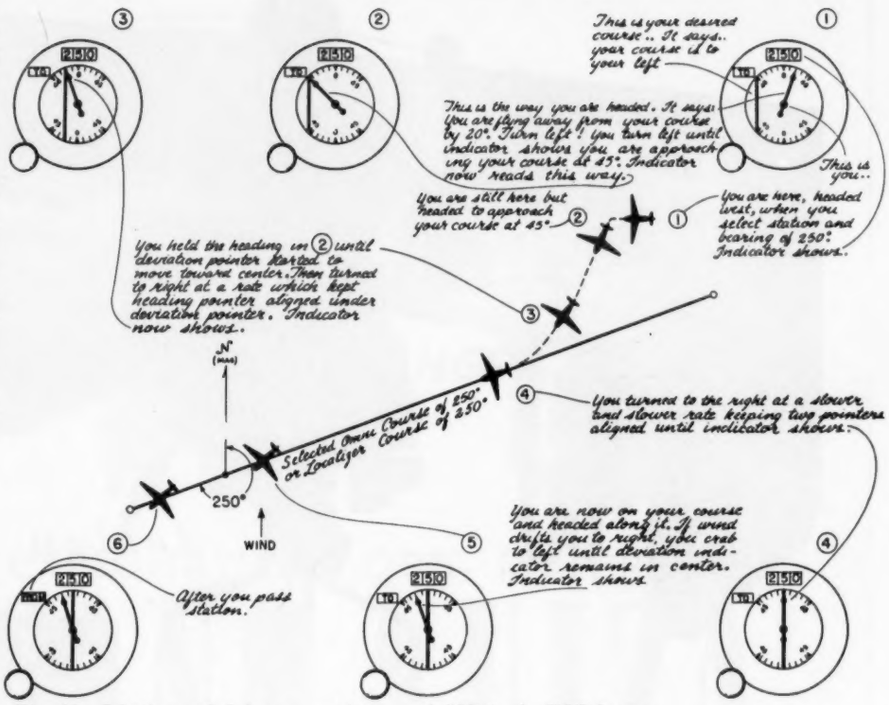

This is your desired course.. It says.. your course is to your left
This is the way you are headed. It says: You are flying away from your course by 20°. Turn left! You turn left until indicator shows you are approaching your course at 45°. Indicator now reads this way.
This is you..
You are still here but headed to approach your course at 45°
You are here, headed west, when you select station and bearing of 250°. Indicator shows.
You held the heading on (2) until deviation pointer started to move toward center. Then turned to right at a rate which kept heading pointer aligned under deviation pointer. Indicator now shows..
N (mag)
Selected Omni Course of 250°
Course of 250°
You turned to the right at a slower and slower rate keeping two pointers aligned until indicator shows.
250°
WIND
You are now on your course and headed along it. If wind drifts you to right, you crab to left until deviation indicator remains in center. Indicator shows
After you pass station.

Fig. 10 : Selecting and flying an omni-course of 250° to the VOR beacon.

electrical information fed to the Autosyn would cause the rotor assembly to stop on the null position equivalent to the magnetic heading or 0°. If, however, the outer stator windings have been displaced by rotation of the course knob through, for example, 10° from the reference point of the Autosyn or 0°, it may be seen that the rotor will then assume an angular position of 10° relative to the Autosyn reference. In this manner, the rotor assembly will always indicate the difference in degrees between the Flux-gate Compass and the course which has been selected on the front of the instrument.

We have described the three standard systems of instrumentation ; namely, minimum, maximum and intermediate. It is easy to realize that it is possible to achieve variations of these basic systems by adding portions of other systems. For example, using intermediate instrumentation, it is possible to add a second Deviation Indicator possibly for the co-pilot and for R.M.I. or ADF type presentation, utilize the RMI Indicator with its associated Omni-bearing Indicator and Radio Magnetic Indicator Amplifier.

The International Civil Aviation Organization (ICAO) has recognized the value of VHF VOR stations. Considerable activity is now under way in the provisioning of suitable ground stations throughout the world. It will, therefore, only be a matter of time before this type of navigation system may be widely utilized.

At the present time, there are several hundred VOR ground stations operating across the U.S. and experience by airlines utilizing suitable airborne equipment proves further that this type of navigation system is a very worthwhile addition to the Aviation family.

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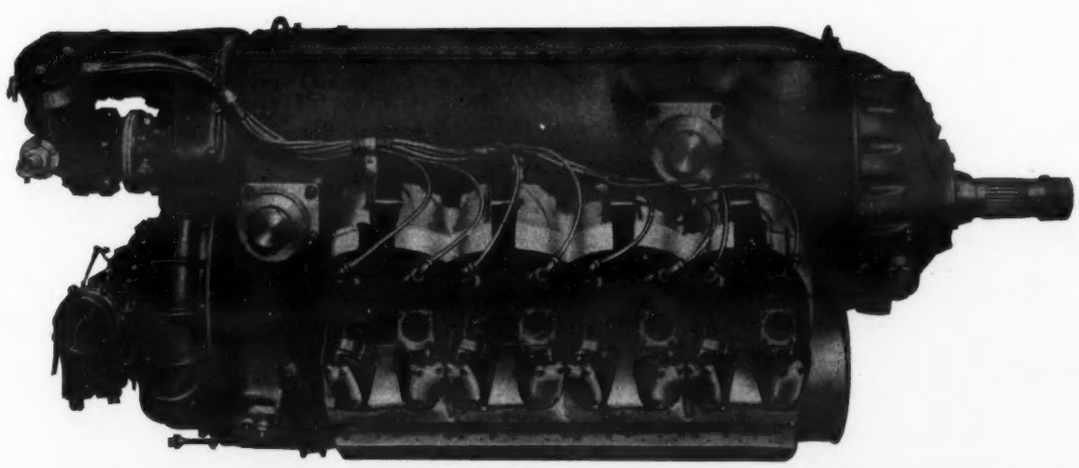

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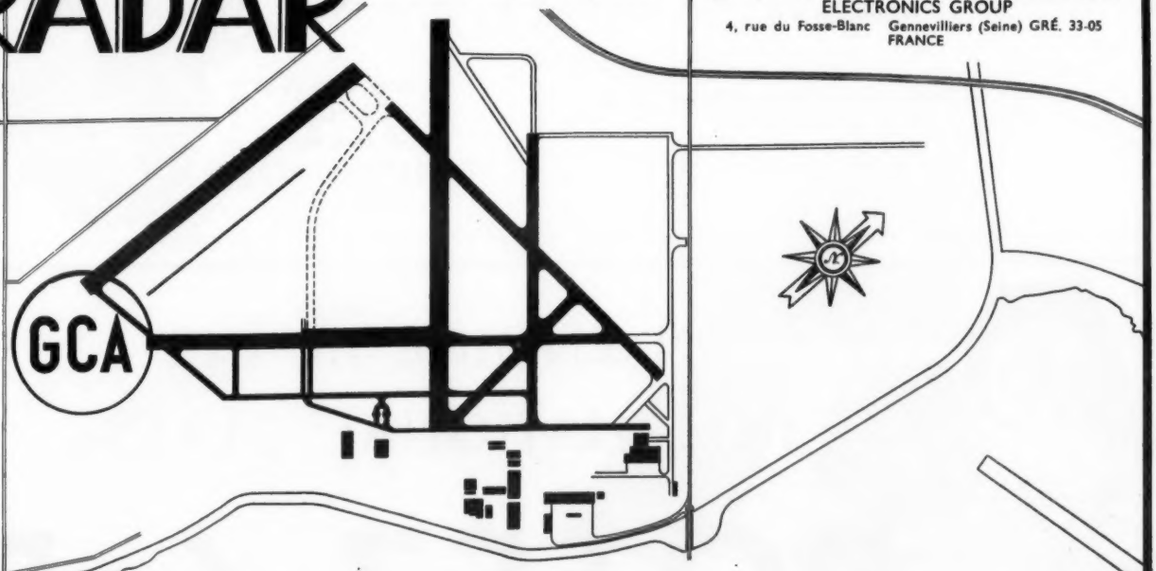

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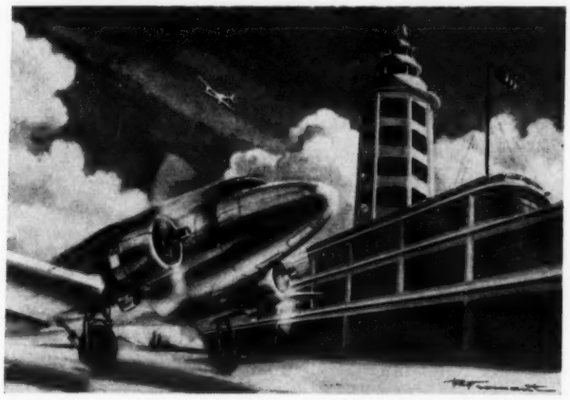

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